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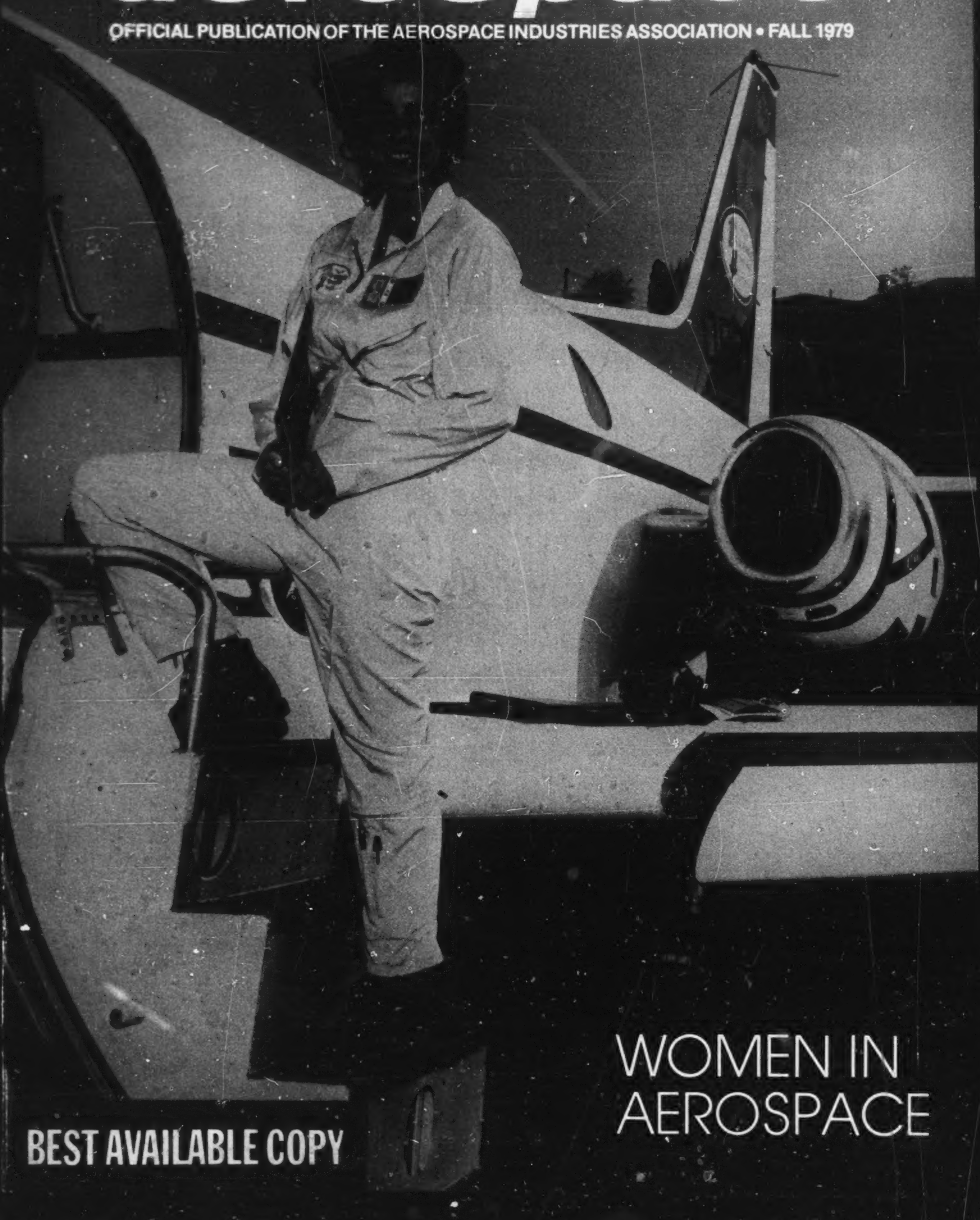

WOMEN IN AEROSPACE

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aerospace perspectives

President Jimmy Carter, *on signing into law the Trade Agreements Act of 1979 at a White House ceremony:*

"I will sign into law . . . perhaps the most important and far-reaching piece of trade legislation in the history of the United States . . . This new legislation strengthens and solidifies America's position in the international trade community. (It) will remove the barriers of fair trade and will reduce unfair trade practices which sometimes cheat those and hamper those who are interested in improving the quality of the world economy . . .

"Our nation has the most productive economy which the world has ever known. Our agricultural abundance and our technological leadership are important sources of America's innate, unshakable strength.

"This legislation will help our manufactured goods and our agricultural products to become more fully competitive on the world market . . . Increased American exports will mean new jobs for American workers, new markets for American business, more secure income for American farmers, a strengthened American dollar, and lower costs for American consumers."

William H. Gregory, *editor of* Aviation Week & Space Technology, *in an editorial comment in that magazine:*

"Some forecasters say a recession is already under way. Others say it isn't here yet but it's coming . . . Whatever happens to the general economy, the aerospace industry should escape relatively unscathed. There are three basic reasons why aerospace has built-in immunity this time around:

- Military funding will at least hold its own in real terms . . .
- U.S. and overseas airline capital investment will at least hold its own . . . Long-term economics will mandate new transports whatever the transient state of the economy . . .
- Business aircraft should also remain relatively immune from recession, at least the turbine-powered end of the spectrum . . .

"Even if a recession does come, the aerospace industry is likely to stay healthy. That in itself is a strong underpinning for the economy."

Langhorne M. Bond, *Administrator, Federal Aviation Administration, in an address to the Aero Club of Washington,*

"So far, nothing in our investigations has led me to conclude that our procedures for certifying and maintaining the safety of aircraft in this country are flawed in any basic way.

"On the contrary, the extraordinary safety record of our country's airlines is proof that the system is basically sound.

"Industry and government may be at cross purposes in some areas—but not in this one. We all want what is best for American aviation, and that is safety."

Lester A. Fettig, *former Administrator of the Office of Federal Procurement Policy in the Office of Management and Budget, writing in the* Washington Post:

"The Pentagon's assigned responsibility is to cope with potential adversaries who . . . spend even larger sums than we do on military versus civilian research and development. The Defense Department has learned since World War II that regular, substantial investments in R&D are the best, if not the only way to keep up with the growing demand for delivery of their services. The civilian agencies largely have not . . . Civilian agencies just don't have modern, disciplined programs to competitively explore, promote and apply new systems for housing, education, nutrition and the host of mission responsibilities to individuals . . .

"The shame is not that the Pentagon puts such a premium on new ways of doing business but that the civilian agencies seem unable and unwilling to do so. The shame is that our nation's base of innovation and creativity—the 'opportunities for professional excitement and achievement' so jealously found in military R&D—remains essentially disconnected from our people's needs for health care and housing and nutrition and transportation."

O. C. Boileau, *president, Boeing Aerospace Company, writing in* Government Executive *magazine:*

"For too long, government has been ignoring the danger signs which could have told us that (an) erosion is under way in the defense business. The health of the U.S. defense industry is deteriorating, and the entire process by which the armed forces acquire their weapons is in jeopardy. That process is producing too few weapon systems. It is producing profits that are too low and frustrations that are too high . . . Too many of our leaders in government seem to be looking the other way, and some defense contractors are looking more intently in the direction of non-defense business.

"One sign that should have sounded an alarm on Capitol Hill is the drastic lengthening of the time it takes to bring a major military system out of the engineering laboratories and get it into the hands of the armed services. Not so long ago, it generally took about four years. Today it takes, typically, 12 years.

"By the time we have placed a new weapon system into the hands of the troops, the technology may be obsolete . . . The complexities of modern weaponry require more time for development and testing . . . but they are exceeded today by the artificial complexities that have been erected by various agencies of the federal government . . . the mass of controls, checkpoints, budgetary hurdles and other assorted regulations imposed by government. I don't question the need for reasonable controls, nor do I pretend their proliferation is entirely to blame for today's situation. But they are taking a heavy toll in time, resources and contractor confidence."

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COVER
Linda Shaffer, radar systems engineer for Hughes Aircraft Co., flew in a modified T-39 Sabreliner to track navigation and data collection procedures. She is taking pilot flight training.

The purpose of AEROSPACE is to:

Foster understanding of the aerospace industry's role in insuring our national security through design, development and production of advanced weapon systems.

Foster understanding of the aerospace industry's responsibilities in the space exploration program.

Foster understanding of civil aviation as a prime factor in domestic and international travel and trade.

Foster understanding of the aerospace industry's capabilities to apply its techniques of systems analysis and management to solve local and national problems in social and economic fields.

AEROSPACE is published by the Aerospace Industries Association of America, Inc., the national trade association of the designers, developers and manufacturers of aircraft, missiles, spacecraft, their propulsion, navigation and guidance systems and other aeronautical systems and their components.

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THE HUMAN FACTOR

BY PAUL THAYER
Chairman and Chief Executive Officer
The LTV Corporation

This guest editorial, based on Mr. Thayer's recent speech to the American Fighter Aces Association, is the first in a series of commentaries on key national issues by senior aerospace industry officials. Their views—together with the views of AIA president Karl G. Harr Jr. which will continue to appear in alternate issues of Aerospace*—are intended to give our readers broader insight into the important matters on the minds of the industry's top leaders.*

I would like to raise the subject of the human element in today's and tomorrow's military aviation. It is a subject that I believe not enough thought is given to, but one that must be highlighted, not only in terms of our Air Force but in terms of our entire military structure. In fact, it is a subject—the role of the individual—that we must begin placing more emphasis on in other aspects of our society as well.

In times of great crisis it is the human factor—the individual with his ingenuity, will and effort—that spells the difference between success and failure. Yet in today's tumultuous age I sense a danger that we are losing confidence in the individual. That in a world of high technology we tend to play down the human factor.

Ironically—or perhaps it was to be expected—we now have developing what can only be classified as a no-risk society, a demand that our environment, our lives, be so structured that nearly all danger of risk is eliminated. It is understandable, of course, that people want assurance that the air they breathe is safe and the products they eat and use present no danger to their health. But how far do we carry this philosophy? Is there not a point where, in adopting such a philosophy, we lose the will to think creatively, to compete, to strive for excellence? Is there not a point where we develop a greater reluctance to take chances in any area of our lives? At what juncture do we become a race of survivors rather than achievers and innovators?

Operation of manned aircraft is a key ingredient in our nuclear strategy. It provides us with flexibility. Unlike the missile, the manned bomber can be launched and then recalled without ever penetrating enemy airspace. If necessary, it can be re-routed, assigned different missions and used more than once. In short, it provides options that any military commander needs and would be unable to obtain otherwise.

There is no way that the importance of the human element can be overstated. As long as you have a thinking human being on the spot, you have something which no machine or technical system of and by itself can provide. And that is the greatest of human gifts, the talent for improvisation, the ability to evaluate a situation and then devise some entirely new way of dealing with it.

The one prediction that can be made with confidence is that the human element will continue to play the major role in our nation's future security. Despite all our shortcomings, despite our apparent concern with nothing but material satisfaction, I don't believe our nation's people will resign themselves to a future based on a no-risk philosophy, a future in which the individual does not have the opportunity to compete, to strive for greater excellence.

With thousands of spectators on hand for the great event, America's first jetliner—the Boeing 707 prototype known as the "Dash Eighty"—lifted off the runway at Renton (Washington) Municipal Airport and climbed steeply over Lake Washington in a preview of the commercial jet age that was to come.

It happened on July 15, 1954 and this year marks the silver anniversary of that important milestone in aviation progress, a momentous development which started a revolutionary transformation of the world air transportation system. The 707 and the other American-built jet transports which followed spurred multifold increases in passenger traffic and reestablished U.S. preeminence in commercial transport manufacture after a tentative challenge from abroad.

The initial American entry in the international jetliner competition made its flight debut five years later than the British DeHavilland Comet, which had flown in 1949 and entered commercial service in 1952. Also in development when the 707 first took to the air were the French Sud-Est Caravelle and the Soviet TU-104. But the American jet was faster and longer-ranging than its European rivals and, most importantly, it could carry almost twice as many passengers. When the world's airlines started placing orders—beginning in 1955—the 707 far outdistanced the foreign contenders. Its prinicpal competitor, in fact, was another U.S.-built jetliner, the Douglas DC-8.

Commercial service with American jet transports was inaugurated in October 1958, when Pan American World Airways introduced the 707 on its transatlantic route. American Airlines started domestic service with the 707 in January 1959, and in September of that year United Airlines and Delta Air Lines initiated DC-8 operations. A third American jetliner, the Convair (General Dynamics) 880, began service with Delta in May 1960. The U.S. jetliner family was expanded in the 1960s, first by derivatives of the three initial types, then by new two- and three-engine designs for short and medium-range operations, finally by the trio of advanced technology wide-bodied jetliners — the Boeing 747, Lockheed L-1011 and McDonnell Douglas DC-10—which are the mainstays of today's long-haul and intermediate range fleet.

The impact of these airplanes on the commercial air transportation system has been extraordinary. Speed, of course, was the primary attraction to the passenger; when they were introduced in 1958, the big jetliners offered roughly twice the speed of the commercial airplanes then in service. Where a transcontinental flight had required 10 hours, the jets cut the time to five hours or less. Transatlantic flight time was reduced from an average 12 hours to less than seven.

These dramatic time savings sparked an air travel boom of astonishing dimension. In 1958, the U.S. scheduled airlines carried 43 percent of all domestic intercity common carrier traffic; by the end of 1978, the figure had risen to 84 percent. A single statistic underlines the enormity of air travel growth in the United States: in 1958, all the domestic airlines combined carried 49 million passengers; in 1978, one airport alone—Chicago's O'Hare—handled 49 million passengers. This year the U.S. airlines will board more than 300 million passengers, a sixfold increase over 1958.

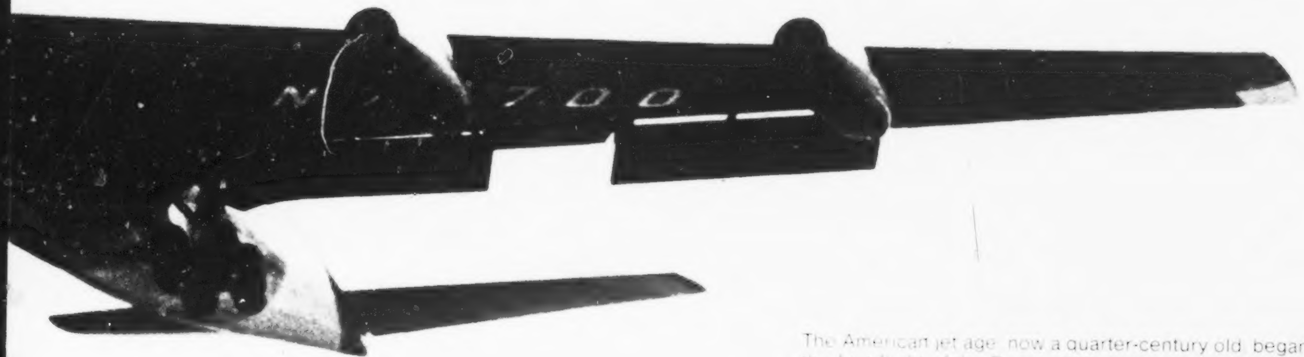
The jetliners' speed and far greater capacity provided exceptional productivity; although it cost more to operate a big jet than predecessor transports, the cost was more than offset by the greater number of passengers per flight and the greater number of flights in a given time span. Productivity and snowballing traffic gains combined to elevate the airlines to high-ranking status among American industries, with attendant benefit to the Gross National Product and employment. U.S. scheduled airline revenues climbed from $2.2 billion in 1958 to almost $23 billion in 1978. Airline industry employment increased over the same span from 143,000 to 329,000.

Jetliner productivity benefited the traveling public because it was a major factor in the airlines' ability to hold the line on ticket prices during a period of spiraling inflation. During the first 20 years of the jet age, the U.S. Consumer Price Index rose more than 125 percent—but the average price of an airline ticket increased only 43 percent. Recent events—in particular sharply rising jet fuel costs—have forced the airlines to seek fare increases, but even with the increases contemplated for the coming year airline tickets will remain a bargain in comparison with other consumer products and services.

Air safety improved significantly in the jet age, although the improvement is only indirectly attributable to the jetliners. The jet is not inherently safer than a propeller-driven airplane, but the jetliners came along at a time of rapidly advancing technology which brought about a number of safety-enhancing developments in the airplane itself and in the national air traffic control system. In 1978, the airlines' safety record was the best among all modes of intercity travel in the United States.

Production of jetliners, which have much higher dollar values than their piston-powered predecessors, has significantly influenced the sales "mix" of the the aerospace industry. In 1958, as now,

U.S. JETLINERS
25th Anniversary



The American jet age, now a quarter-century old, began with the first flight of the Boeing 707 prototype on July 15, 1954

U.S. aircraft builders predominated in worldwide sales of airliners, but in dollar value terms commercial sales represented a minor part of the industry's total sales. The industry's financial health was largely dependent on contracts with the military services, which in 1958 accounted for more than 90 percent of total industry sales. This year it is estimated that sales to the government will constitute only 55 percent of the total. There are other factors involved in this improved sales balance, but the main item has been the rapid growth in sales of high-value jetliners.

Finally, U.S. domination of the world jetliner market has had a beneficial impact on the U.S. economy in its contribution to the nation's trade balance, particularly in recent years when the U.S. as a whole experienced large trade deficits. In 1958, exports of commercial airliners amounted to $165 million. Last year, jetliner sales abroad totaled more than $2.5 billion and represented 25 percent of all U.S. aerospace exports. With a trade surplus of $9 billion in 1978, the aerospace industry led all U.S. industries in positive contribution to the balance of trade and jetliner sales to foreign airlines played an important part in the industry's international trade performance.

Since 1958, when American-built jetliners were introduced to airline service, passenger traffic on U.S. airlines has increased sixfold.

The federal government now spends something like a billion dollars a year for forms, another billion for directives telling you how to fill them out, and another $1.7 billion to store them.

Add up all the forms annually issued by federal, state, and local governments and they come to a staggering 2 billion pages. That's about 10 pages for every man, woman, and child in the United States.

There are 16 warehouses of federal records around the country containing a total of more than 12 million cubic feet of paper. Piled up, some analysts have appropriately pointed out, this material would form a structure equal in girth and a dozen times as tall as the Washington Monument. And, of course, the volume keeps growing.

Overall, American business spends approximately $30 billion a year on federal paperwork, responding to requests and requirements for information from payrolls to pensions to production, from energy to equal opportunity to the environment, from safety to sales expectations to annual surveys of scientific and technical personnel.

The 10,000 largest firms in the country expend hundreds of millions of man-hours gathering, processing, and preparing the vast range of information involved, then storing material that must be retained. The bill for this vast effort plus related costs such as computer support comes to an estimated $10 to $12 billion a year, or an average of more than $1 million for each company.

Some 5 million small businesses spend $15 to $20 billion, or an average of more than $3,000 each, which in some cases may be at least as burdensome as the much larger costs to larger organizations.

Even these astronomical numbers cover, of course, only a minor portion of the total cost of complying with federal and local regulations in many fields. Paperwork is the administrative tip of the iceberg. But it is clearly a sizable one that many people in government as well as business today feel could be cut back significantly.

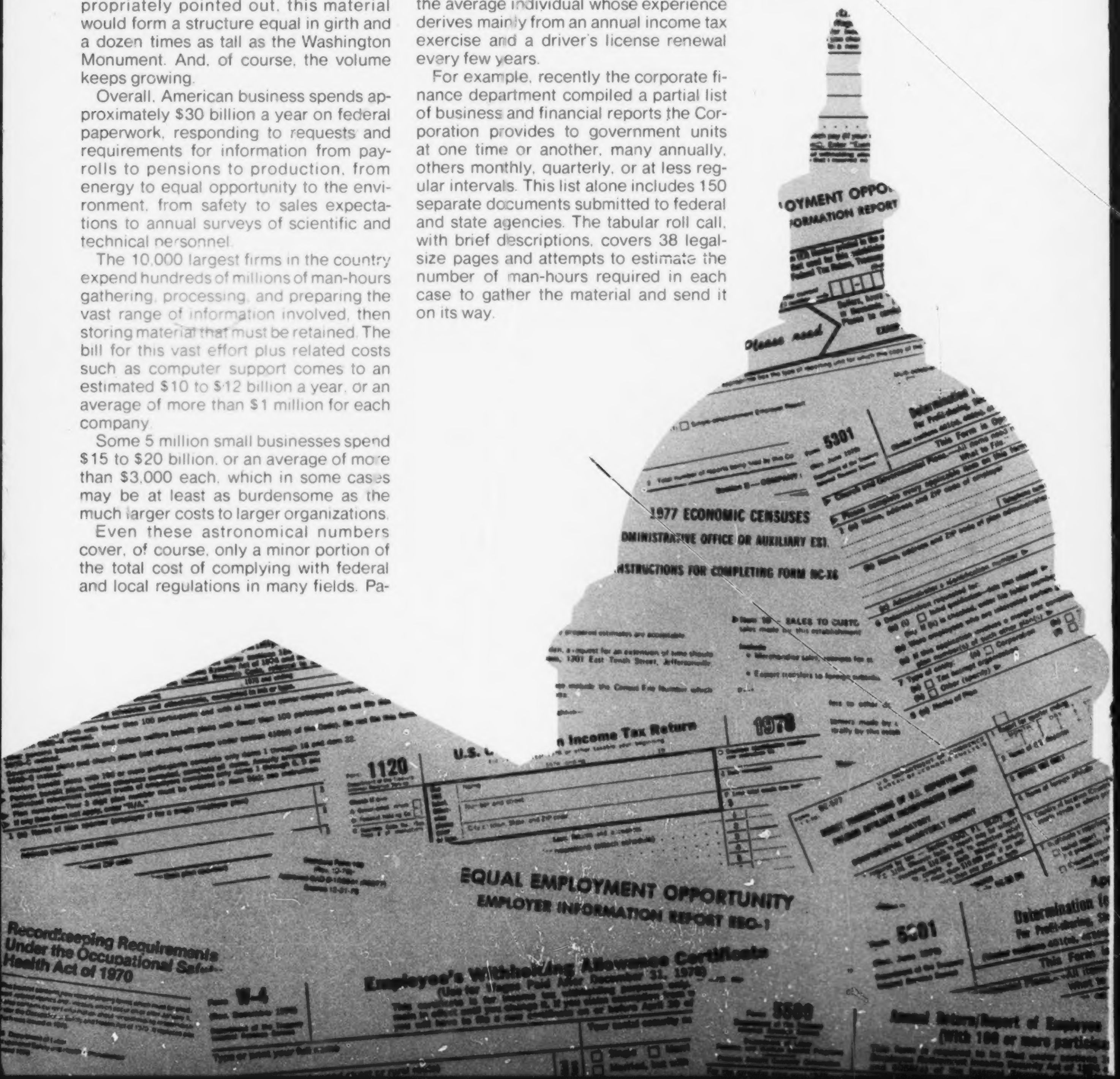
At Martin Marietta headquarters, and in locations around the country, government paperwork is an ever-present fact of life. That's not to say it's all bad; some in various fields is clearly necessary. And in the conduct of government contracts, it's an essential of doing business.

On the other hand, in recent years the government paper workload has reached proportions that hardly seem credible to the average individual whose experience derives mainly from an annual income tax exercise and a driver's license renewal every few years.

For example, recently the corporate finance department compiled a partial list of business and financial reports the Corporation provides to government units at one time or another, many annually, others monthly, quarterly, or at less regular intervals. This list alone includes 150 separate documents submitted to federal and state agencies. The tabular roll call, with brief descriptions, covers 38 legal-size pages and attempts to estimate the number of man-hours required in each case to gather the material and send it on its way.

Not included in the listing, which was restricted to only one busy segment of the corporate reporting burden, were such extremely heavy areas as taxes, pensions, equal opportunity, safety and health, the environment, and Securities and Exchange Commission requirements. Even the segment that was compiled, however, yielded a conservative estimate of 34,400 man-hours expended on an annual basis. That's about 17 man-years.

Experts differ on how to translate government-paperwork man-hours into dol-


OYMENT OPPO
ORMATION REPORT
5301
1977 ECONOMIC CENSUSES
OMINISTRATIVE OFFICE OR AUXILIARY EST.
SALES TO CUST
Income Tax Return
1978
U.S.
1120
EQUAL EMPLOYMENT OPPORTUNITY
EMPLOYER INFORMATION REPORT EEO-1
Recordkeeping Requirements
Under the Occupational Saf
Health Act of 1970
Employee's Withholding Allowance Certificate
W-4
5500
Determination
Annual Return/Report of Employee
(With 100 or more partic

Government Paperwork – What's the Cost? Industry Spends Millions Yearly

lars, and the most candid conclusion probably is that it's difficult to do so with maximum accuracy. The figure $30 an hour does, however, appear to provide reasonably for managerial, planning, professional, and clerical time-and-benefits. By that yardstick, then, the admittedly fragmentary list of 150 reports costs Martin Marietta something like $1 million a year.

How much is the Corporation's overall bill for government recordkeeping and reporting? Nobody can say with certainty, although some estimates have been made. So extensive and all-pervasive is the workload that few corporations have undertaken the awesome task of analyzing it in detail. Most figures available were developed in hearings and surveys by the government's own Commission on Federal Paperwork, set up a few years ago in response to stentorian cries of anguish from the business community and others.

The commission developed a rule of thumb, which it called "an imprecise measurement," for estimating typical costs for businesses of various sizes. The estimate for Martin Marietta comes to $6.5 million a year. Kaiser Industries, a diversified corporation farther down in the Fortune 500, conducted a painstaking two-year study and came up with its own price tag of $4.5 million, about 20% above the commission estimate in its case.

Stephen Laycock, Martin Marietta's corporate director of accounting policies and procedures, is responsible for many of the business reports that go to government agencies. His office prepared the existing million-dollar listing and also took a general look a while back at other reporting requirements.

"From our own experience," says Steve Laycock, "and what we've seen in other parts of the corporation, we estimate the total cost could be as high as $10 million a year. Some of the reporting seems unnecessary, some duplicates material we've already submitted in another form so we have to reprocess it, and the volume increases year by year. It's a real problem."

It's hard to find anyone who disagrees these days.

"Businesses rightly complain that more information than necessary is collected," concludes the paperwork commission. "As a result, they are drowning in a sea of paperwork and red tape."

The business community—led by such organizations as the Business Roundtable, the U.S. Chamber of Commerce, and the National Association of Manufacturers—has been calling for some measure of realistic relief before the tide rises even higher. Trade associations and other industry-supported groups such as the Business Advisory Council on Federal Reports and the Citizens Committee on Paperwork Reduction have been working with government agencies on a case-by-case basis in an effort to pull in the reins.

Now Congress, where some people feel the primrose path of paperwork begins, is taking a hard look at the problem. Some 20 bills have been introduced, embodying a variety of approaches including the revolutionary concept that government should pay the costs for material it requires.

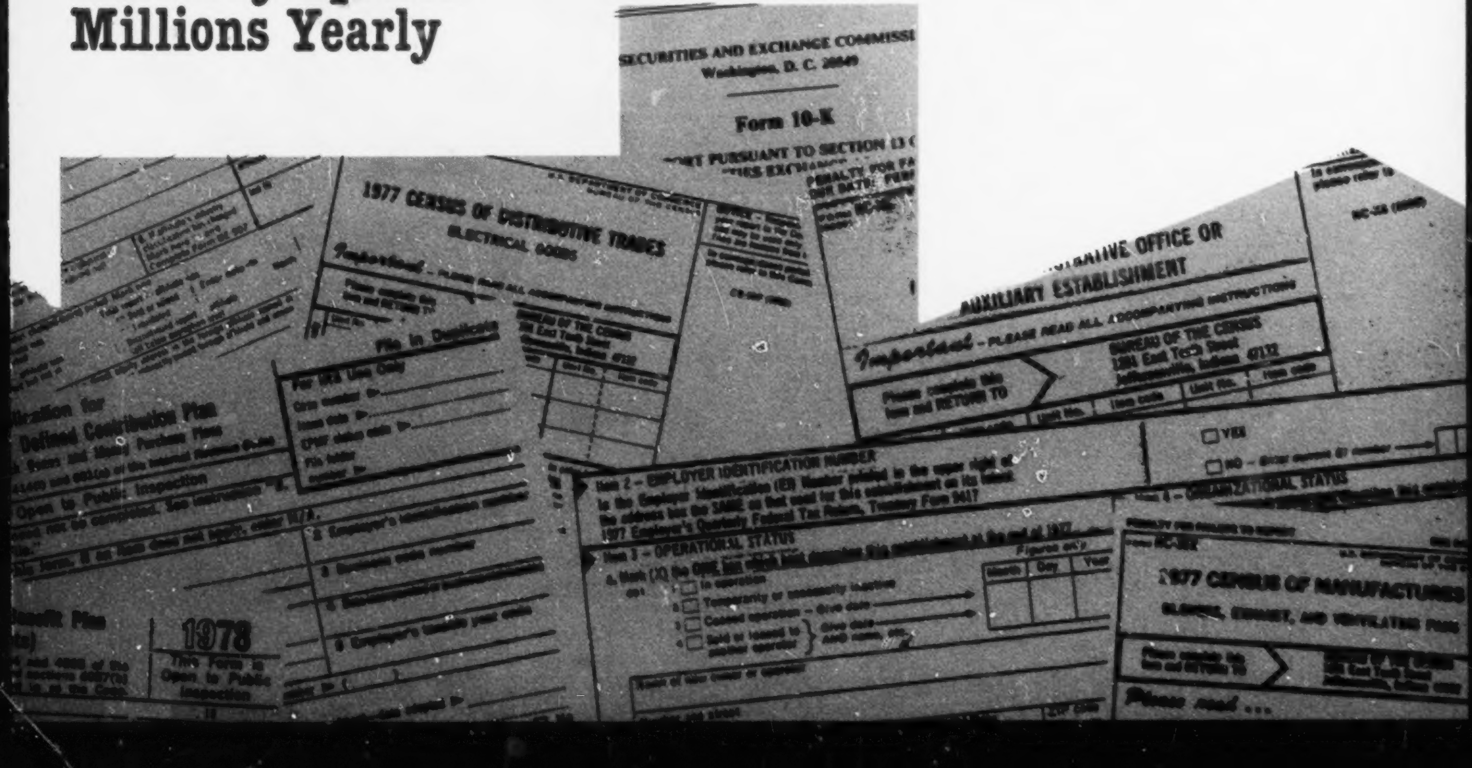
The bill most likely to become law, experts say, takes a less radical approach. Sponsored in the House of Representatives by Rep. Frank Horton (R., N.Y.) with the co-sponsorship of Reps. Jack Brooks (D., Tex.), Tom Steed (D., Okla.), and Richardson P[illegible] (D., N.C.), it establishes (1) a central office to hold the lid on federal information requests, which come from a multitude of separate agencies, and (2) a computerized "information locator system" to keep track of information that's already in the files somewhere and so, supposedly, doesn't have to be asked for again. The Department of Defense is running a system of this kind that could be swung into action for the government as a whole.

Sen. Lawton Chiles (D., Fla.), who is expected to introduce a companion bill in the Senate, has been conducting a paperwork crusade including insistence on the inclusion of red-tape "impact statements" in new legislation.

Even with these efforts, however, neither Senator Chiles nor anyone else sees a quick or easy solution to a widespread problem that has grown over many years.

"It is kind of like fighting a pillow," he says. "You take a lick at one side and it just puffs out on the other. The task of cutting red tape and reducing paperwork has more political support than any activity we could possibly get into, and yet we find it more and more tremendously difficult to try to do anything about it." ☐

Reprinted from *Today*, the quarterly magazine of Martin Marietta Corporation.


SECURITIES AND EXCHANGE COMMISSI
Washington, D. C. 20549
Form 10-K
1977 CENSUS OF DISTRIBUTIVE TRADES
ELECTRICAL GOODS
AUXILIARY ESTABLISHMENT
Item 2 – EMPLOYER IDENTIFICATION NUMBER
Item 3 – OPERATIONAL STATUS
Open to Public Inspection
1978
This Form is Open to Public Inspection
1977 CENSUS OF MANUFACTURES
Please read ...

The Ninety-Nines are nearing fifty. On November 2, the international organization of licensed women pilots will celebrate the 50th anniversary of its founding with ceremonies at the site of old Curtiss Field, Valley Stream, Long Island, New York, where the organizational meeting took place in 1929.

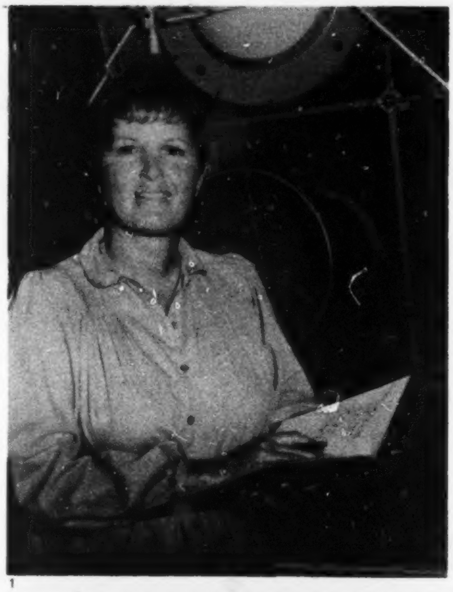
There were, at the time, 117 women pilots in the U.S. and 99 of them responded to an invitation to organize—hence the name. Amelia Earhart was elected first president. In 50 years, the ranks of the Ninety-Nines have increased fifty-fold, to more than 5,000. The number of American women pilots has multiplied at an even greater rate; there are now more than 50,000.

Beginning at Curtiss Field—which today is a shopping mall—the Ninety-Nines established high professional standards and demonstrated their abilities as balloon, airplane and—later—helicopter pilots. They pioneered careers for women in aerospace, now a large and expanding movement.

At an ever-increasing rate, women are taking seats in airline cockpits. They have won places in NASA's astronaut corps. Except for the Marine Corps, the military services have opened their ranks to women pilots. In the aerospace industry, women are no longer confined to secretarial jobs; they hold key positions, as scientists, engineers, administrators, lawyers, sales/marketing personnel and public relations/advertising officials.

A sampling of women in industry includes:

- Charcy Evans Black, Vought Corporation, a lead flight test engineer for the Scout launch vehicle.
- Margaret A. Mead, Gates Learjet Corporation, district sales manager in four Western states.
- Mrs. Ruth Naber, Sundstrand Corporation, group engineer for actuation systems in the company's Advanced Technology Group.
- Theresa Ann Sheehan, General Dynamics Corporation, an aerodynamics engineer working with the Advanced Wing Design Group.
- Dr. Dora Strother, Bell Helicopter Textron, chief of the company's Human Factors Division and Cockpit Arrangement Group, who is also International President of The Whirly-Girls, Inc., the international association of women helicopter pilots.
- Shirley Holmgreen, The Boeing Company, aeronautical engineer and group supervisor for the 737 Aerodynamics Staff and for 727/737 Product Development.
- Susan A. Rubin, ITT Gilfillan, a senior design engineer assigned to the company's land based air defense program being developed for the Swedish government.
- Rita Marie Lavelle, Aerojet Liquid Rocket Company, director of communications responsible for external and internal communications/public relations for the company's products.
- Patti Mancini, Rockwell International Space Systems Group, vice president for external affairs and communications.
- Mrs. Louise Gilbreath, Vought Corporation, supervisor of the Corporate Com-



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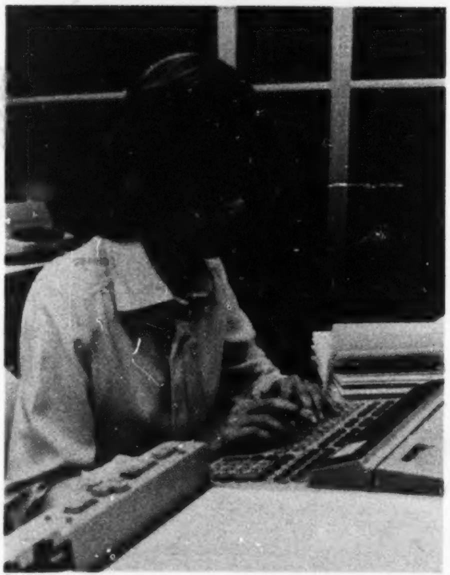

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1. At Rockwell's Rocketdyne Division, Pat Swanson is a project engineering manager.

2. At General Dynamics, Theresa Ann Sheehan is is an aerodynamics engineer in Advanced Wing Design.

3. Dr. Dorothy M. Simon is Vice President, Research for AVCO Corporation.

4. Sue Matheis and Don Miller are pilots/ reporters for Station KMOX-CBS Traffic Watch in St. Louis, Missouri.

5. Coast Guard LTJG Colleen Anne Cain (left) pilots a Sikorsky Sea Guard helicopter, and Lt. Vivian Suzanne Crea is qualified as a C-130 Lockheed Hercules pilot.

6. Captain Cheryl Faye Peters, one of the six women pilots flying for Piedmont Airlines.

7. In 1978, McDonnell Douglas Corporation's airplane/helicopter pilot/flight test engineer Nelda K. Lee received the American Institute for Aeronautics and Astronautics' Young Professional Award for her contribution to the design of the F-18 graphite/epoxy wing.

8. At The Boeing Company, aeronautical Engineer Shirley Holmgreen is group supervisor for the 737 Aerodynamics Staff and 727 and 737 Product Development.

9. At Martin Marietta's Michoud Operations in New Orleans, Susan D. Lemeshewsky is a senior engineer in materials engineering.

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golden jubilee
1979
the ninety-nines

WOMEN IN AEROSPACE

7

9

munications Department.

- Cynthia L. Baker, Hughes Aircraft Company, corporate advertising manager.
- Dr. Dorothy M. Simon, AVCO Corporation, corporate vice president-research, who has oversight responsibility for the R&D functions of the company's nine technology-based divisions.
- Sally H. Bath, Aerospace Industries Association, chief statistician for the Economic Data Services. Ms. Bath is also responsible for preparation of AIA's annual publication Aerospace Facts and Figures.
- Jean Ross Howard, Aerospace Industries Association, director of helicopter activities and editor of the AIA Directory of Helicopter Operators and the Directory of Heliports. A member of the Ninety-Nines, Miss Howard was founder and first president of The Whirly-Girls, Inc.
- Barbara J. Boykin, Aerospace Industries Association, administrator for two of the association's technical committees: the National Aerospace Standards Committee and the Aerospace Sector Committee of the American National Metric Council.
- Evelyn Bryan Johnson, manager of Tennessee's Morristown Flying Service, a veteran of 25 years in aviation who has been named by the Federal Aviation Administration the 1979 Flight Instructor of the Year.

Women are also participating in advanced training programs designed to prepare candidates for upper level aerospace industry positions. Some examples:

- Susan D. Lemeshewsky, Martin Marietta Corporation, a senior materials engineer who has won a competition for a year's assignment in the company's Technical Operations Intern Program.
- Karen Leslie Key, Bell Helicopter Textron, an executive staff assistant in the Commercial Marketing Department who is receiving advanced training to become a regional marketing director.
- Natalie J. Krahl, General Dynamics Corporation, assistant project engineer in the Range Systems Project Office, whose management ability won her company sponsorship in the UCLA Engineering Executive Program, a two-year course.

In the airline industry, women pilots represent a small segment of the total pilot complement, but they are making inroads into what, not long ago, was an entirely male occupation. There are 110 women airline pilots and most of the major airlines have at least one.

In government aerospace operations, six women recently scored a breakthrough when they became NASA's first women astronauts. All mission specialists—scientists and engineers who handle multiple tasks associated with handling Space Shuttle payloads and experiments—the six include: Dr. Anna L. Fisher, an M.D. specializing in emergency medicine; Dr. Judith A. Resnik, electrical engineer; Dr. Kathryn D. Sullivan, geologist; Dr. Margaret Rhea Seddon, a surgeon and a member of the Ninety-Nines; Dr. Shannon W. Lucid, biochemist; and Dr. Sally K. Ride, physicist.

Among non-astronaut women in aerospace programs, Ann F. Whitaker is chief of the Physical Sciences Branch at NASA's Marshall Space Flight Center; Barbara G. Askins, 1978 National Inventor of the Year, is a research chemist in Marshall's Space Sciences Laboratory; Trudy Tiedemann is a public information specialist at NASA's Dryden Flight Research Center, Jennifer L. Baer is propulsion system project engineer for the HiMat (Highly Maneuverable Aircraft Technology) program in flight status at Dryden; Harriet Jacqueline Smith is project manager for NASA's F-14 research program; JoAnn Morgan is an electronics engineer on the Space Shuttle Launch Processing System; Judith A. Anderson is a systems engineer on the Space Shuttle program at Kennedy Space Center; and Ann Montgomery is site manager for the Orbiter Processing Facility at Kennedy.

In government aviation activities, more than five percent of the Federal Aviation Administration's corps of air traffic controllers are women—more than 1,500 of the 27,000 total. In lesser numbers, women are working in such other FAA jobs as electronic technicians, engineers and flight standards inspectors; there are 250 women in those categories. Among women executives in FAA are Joan Barriage, chief of the Flight Standards Division, Great Lakes Region, and Mary Jo Oliver Knouff, acting chief of the FAA Aviation Education Programs Division.

In a 1977 development, belated recognition was granted the Women Air Force Service Pilots (WASPs) who, during World War II, flew 60 million miles on ferry, tow target and test flight missions to free male pilots for combat duty. Congress passed and President Carter signed a bill authorizing veteran status for the remaining 800 eligible WASPs.

Following in the WASPs' footsteps, a large number of women are now serving as active duty pilots with the military services and the Coast Guard. In 1973, the Navy became the first service to open aviation training to women; today there are 27 women officers wearing the naval aviator's badge. The Army now has 40 women aviators, 20 of them warrant officers, all of them rated in rotary-wing aircraft. In the Air Force, there are 22 women officer pilots and six navigators; women are also serving as crew chiefs and weapons controllers. The Coast Guard has three women aviators, two of them helicopter pilots and the third a transport pilot.

Women in aerospace have come a long way in half a century and they owe their current status to the pioneering effort of the Ninety-Nines. In a salute to the Ninety-Nines and to women pilots in general, Senator Barry Goldwater said:

"It is impossible for me to overestimate what women flyers have meant to the development of aerospace pursuits in the years past. And it is hard to imagine what heights they will help the industry achieve in the future."

10. The 1978 National Inventor of the Year, Barbara S. Askins is a chemist at the NASA's Marshall Space Flight Center.
11. Susan Rubin is a senior design engineer at ITT Gilfillan.
12. Karen Leslie Key is demonstrator pilot/executive staff assistant in advertising and market research at Bell Helicopter Textron.
13. Surgeon Dr. Margaret Rhea Seddon, one of NASA's six women astronauts.
14. At Sundstrand Corporation, Ruth Naber is group engineer for the Advanced Technology Group.
15. Margaret Mead, district sales manager at Gates Learjet, is regional sales manager for new business jet aircraft.
16. The youngest U.S. airline pilot, 22-year-old Kim Goodman, flies Western Airlines Boeing 737s as a second officer
17. At LTV's Vought Corporation, Charcy Evans Black is lead flight test engineer. She monitored eight of the last thirteen launches of the Scout rocket.

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1979:

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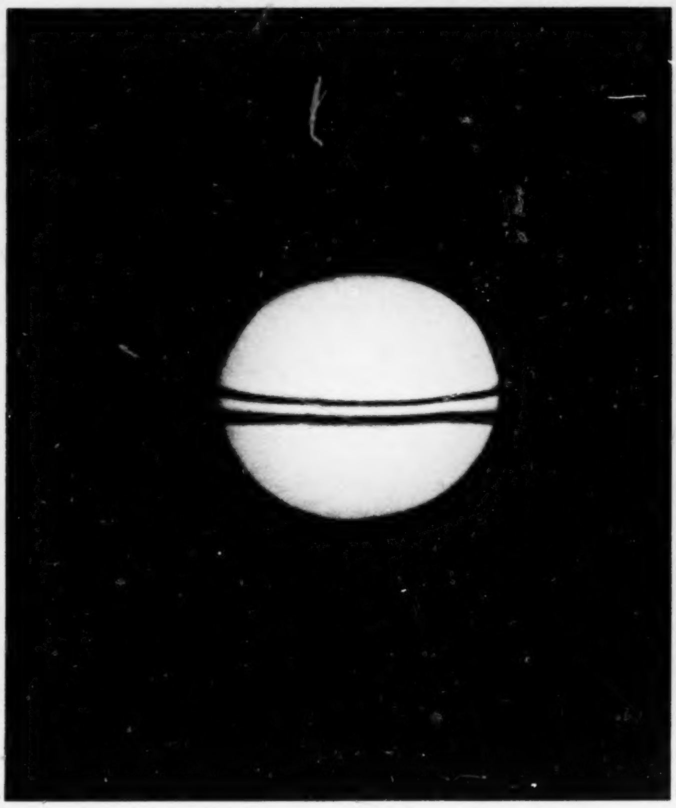

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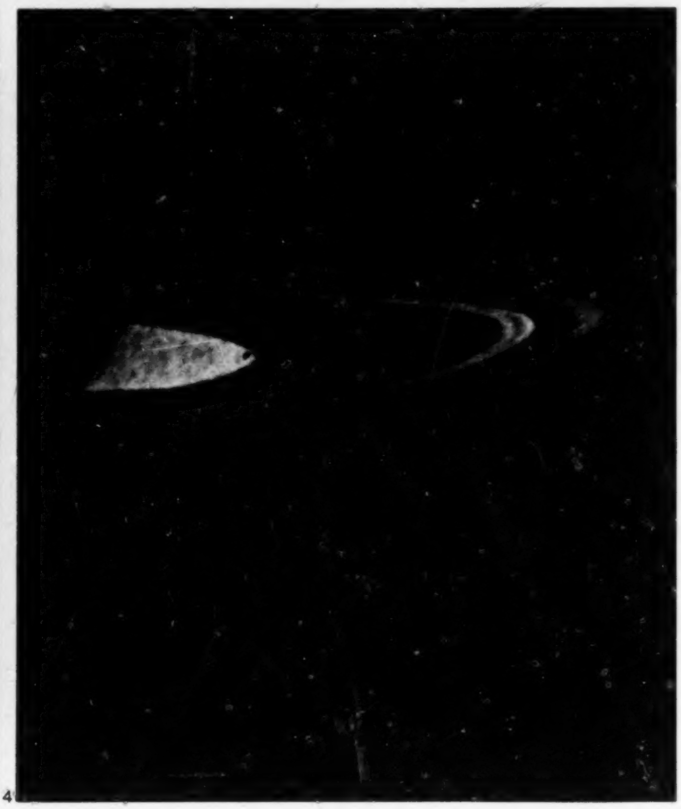


4

PLANET YEAR

1. Voyager 1 took this picture of Jupiter and two of its moons, Io (left) and Europa. The immensity of the Jovian system is underlined by the fact that the moons, seemingly close to Jupiter, are actually hundreds of thousands of miles distant and the planet itself was 12.4 million miles from Voyager when the photo was taken.
2. This is a historic photo of a volcanic eruption on Jupiter's innermost moon, Io, the first volcanic activity found outside Earth. The related image is a computer-processed blow-up of the 100-mile-high eruption.
3. From a distance of 1.8 million miles, Pioneer 11 took this image of Saturn, its rings and its largest moon, Titan (upper left).
4. This Pioneer 11 view of Saturn's rings shows detail never before seen. The spacecraft's imaging equipment and other instruments discovered two hitherto unknown rings.

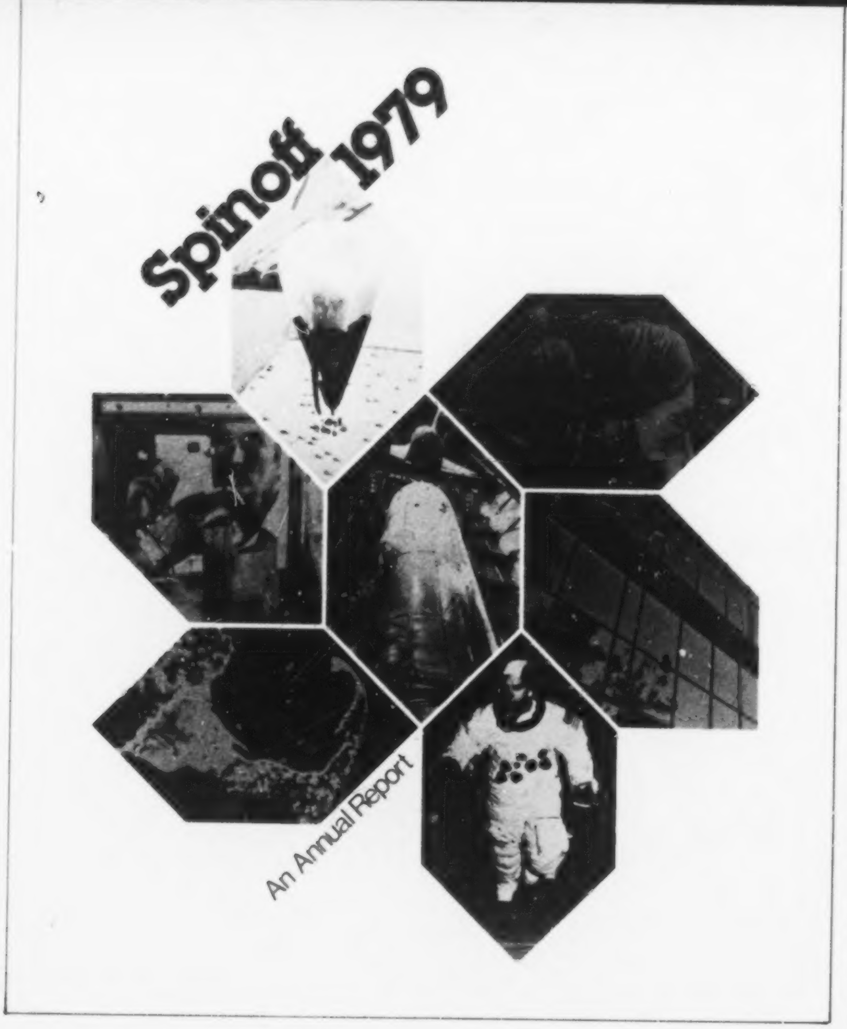
For NASA, 1979 has been "The Year of the Planets," with seven different spacecraft returning photos and data from Venus, Mars, Jupiter and Saturn. ■ Over an eight-month span from January through August, Voyagers 1 and 2 provided thousands of images and a wealth of other information about the superplanet Jupiter and several of its moons. A scientific highlight was the discovery of live volcanoes on the moon Io, the first identification of volcanic activity anywhere except on Earth. ■ Most recent of the planetary encounters was the first visit to Saturn of an Earth vehicle, Pioneer 11's September fly-by of the multi-ringed planet after a six-year, two-billion-mile journey. The Pioneer mission was especially exciting to the scientific community because Saturn is so far from Earth it cannot be viewed in desired detail from ground-based telescopes. Pioneer 11, built by TRW Inc., sent back scores of photographs and volumes of instrument data which will be undergoing analysis for months. Among preliminary findings were discovery of two new rings around Saturn and identification of a new object orbiting the planet, perhaps a very small 11th moon. ■ Scientifically, the information supplied by these and other spacecraft is immensely important and it also has potential for practical application. Through "comparative planetology"—relating phenomena on one planet to conditions on another—scientists are learning more and more about the processes which govern Earth, a step toward future management of these processes to man's advantage—control of weather, for example. ■ NASA's planetary exploration program will continue next year, when Voyager 1 will reach Saturn, and again in 1981 when Voyager 2 arrives at the ringed planet; these encounters will amplify the information provided by Pioneer 11. Jupiter will get a more extensive look in the mid-1980s, when two Galileo spacecraft—an orbiter and an instrumented probe which will drop through the Jovian atmosphere—begin their investigations; the thousand day trip to Jupiter will get under way late in 1982 or early in 1983. Distant Uranus, some two billion miles from Earth, will be close-encountered for the first time in 1986 by Voyager 2.

Grumman's Dormavac, a spinoff from the company's work on space environmental control, provides a commodity-preserving environment for long-term protection of perishables without freezing.

Spinoff 1979

The *American Enterprise*, a high-speed crewboat designed to serve offshore oil rigs, is powered by a Rocketdyne waterjet propulsion system which is a direct derivative of space-use turbopumps.

▲ McDonnell Douglas subsidiary Vitek Systems, Inc. is producing for hospital use the AutoMicrobic System, a laboratory aid which sharply reduces the time required to detect and identify harmful microorganisms in human specimens. The system derived from a McDonnell Douglas space medical study conducted for NASA.



To get the great thrust needed to boost spacecraft to orbit, space launch vehicles burn enormous amounts of fuel—tens of thousands of gallons each minute. The job of feeding liquid propellants to the rocket engines under high pressure is handled by systems called turbopumps.

These high capacity products of aerospace research and development are finding new utility in non-aerospace applications. Rocketdyne Division of Rockwell International, the principal manufacturer of space-use turbopumps, is now producing direct derivatives called Powerjets as propulsion systems for high speed boats and small ships. These jetlike systems gulp large amounts of water, increase its pressure, then expel it at high velocity to generate propulsive thrust. Powerjets are in service aboard The Boeing Company's 45-knot, 300-passenger Jetfoil boats, which are providing high speed transportation in several European, South American and Asian locales. The latest application of the Powerjet is in a 38-knot crewboat designed to serve the offshore petroleum industry.

The Powerjet line is one of some 60 examples of aerospace technology transfers contained in NASA's Spinoff 1979, an annual publication which details how the secondary use of technology originally developed for aerospace programs is being reapplied in a broad variety of civil-use products and processes. Thousands of spinoffs have emerged since the 1962 establishment of NASA's Technology Utilization Program, which seeks to promote wider use of already-developed technology and thus realize a dividend on the national investment in aerospace research and development.

Among other examples of innovations derived from aerospace technology are these:

The technology once used to locate a spacecraft in orbit and maintain a fixed position is being applied to deepsea oil drilling operations. For deepsea work, oil explorers use drillships, connected to the wellhead thousands of feet below by a cylindrical steel tube through which the drilling equipment is lowered. The drillship must maintain a precise position, often for months; excessive ship movement could snap the drill tube at a cost of millions. Both Honeywell Inc. and TRW Inc. have adapted spacecraft positioning systems to this need; the systems determine the position of the ship relative to the wellhead and a computer directs the ship's engines or thrusters to nudge the vessel forward, backward or to either side to maintain the precise position desired.

Crude oil moving through the Alaska pipeline must be kept at relatively high temperature to maintain fluidity. General Electric Company's Space Division provided the answer with a highly effective insulating material called Therm-O-Trol. GE also produces Therm-O-Case, a multilayer insulating system for Alaskan oil wells which prevents transfer of heat from hot crude oil to the surrounding permafrost soil; heat transfer could melt the permafrost and cause surface dislocations that might destroy the well casing. Therm-O-Trol and Therm-O-Case stemmed from GE Space Division's heat transfer/thermal control work on Gemini, Apollo and other NASA programs.

Lockheed Missiles and Space Company developed for NASA a Laser Doppler Velocimeter (LDV) for measuring airflow disturbances in wind tunnels and in flight. The system is now being used in a NASA/Federal Aviation Administration safety program involving study of normally invisible vortices, air whirlpools at the tips of a jetliner's wing which can be hazardous to small airplanes following closely behind. The LDV also has civil utility as a highly-accurate wind measurement device for meteorological use or as a means of tracking smokestack pollution dispersion patterns.

The experience Grumman Corporation gained in developing the environmental control system for the Lunar Module has been reapplied in a commercial product that can preserve perishable commodities for long periods without freezing them. Called Dormavac and marketed by Grumman Allied Industries, the system provides a commodity-preserving environment within a large aluminum trailer which can be transported by truck, rail or ship.

McDonnell Douglas Corporation conducted a NASA study aimed at development of an automatic system for detecting and identifying pathogens, or harmful micro-organisms, a system intended for health care on long-duration space missions. After years of additional research and development, the company has brought the system to the commercial market. Called the AutoMicrobic System (AMS), it identifies the presence of pathogens and specifies the type in a fraction of the time required by traditional laboratory methods. The system also minimizes human error, increases laboratory output because it can handle a great many specimens at one time, and reduces patient stay-time in the hospital. Already in service at a number of hospitals, AMS is produced by Vitek Systems, Inc., a McDonnell Douglas subsidiary.

Spinoff 1979 is a 116-page paperback volume which treats both spinoff and direct-benefit space applications in text/photo fashion, with 156 photographs in full color. It is available at $4.10 per copy from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

AEROSPACE AND

In the national effort to reduce the United States' dependence on foreign oil through development of alternative energy sources, the aerospace industry is playing a significant role. By virtue of its long experience in high technology programs, the industry brings to the energy quest a unique and important capability for innovative development and high technology program management. The nature of that capability and how it is being applied is the subject of a study by Aerospace Industries Association's Aerospace Research Center. The study, entitled "The Energy Mission: An Aerospace Perspective," is excerpted on the following pages. Copies of the full report may be obtained by writing Allen H. Skaggs, Director, Aerospace Research Center, 1725 DeSales Street, N.W., Washington, D.C. 20036.

Efficient energy conservation, use and storage have long had a high priority for designers of aricraft and space systems. Powered flight itself is a critical exercise in energy management. . . . Energy management became an even greater challenge as man sought to extend flight beyond Earth's atmosphere. The aerospace community again responded, this time with powerful rocket engines based on advanced technology and new fuels. Complex long-term space missions created a demand for highly reliable onboard systems for generating electric power, precisely managing its consumption and providing for its storage. Photovoltaic cells, fuel cells and lightweight high capacity batteries were developed by NASA and aerospace companies to meet these needs. Advanced power and propulsion systems for future space missions are under continual development . . .

Aerospace companies hold Department of Energy (DoE) contracts in nearly every emerging technology. . . . The unique character of the industry suggests that its potential for solving energy problems is just beginning to be tapped. Aerospace companies have played a central part in maintaining national security since the early days of aviation. They have pioneered mankind's expansion into space. They have repeatedly accomplished complex missions in the national interest. These experiences have molded a high technology industry with these particular attributes for successfully pursuing the goal of assured national energy efficiency:

- *Management of complex long-term projects*
  Single aerospace programs have often run into billions of dollars and have taken more than 10 years from concept to completion. Effective management of these programs has honed the dynamic management skills of the industry —skills which are directly applicable to the many programs and projects DoE is pursuing.
- *Strong government/industry relationship*
  Long-term joint pursuit of national defense and aerospace goals has developed an effective planning and policy-making relationship between the industry and the government. This ability to successfully work together on government-funded programs is essential for solution of energy problems.
- *Research laboratories*
  The continuing development of more advanced weapons systems and space vehicles requires the industry to push forward many state-of-the-art technologies. In many of its products, revolutionary advances in performance and capability are required. To meet this demand, the industry maintains many high quality research laboratories which have a proven record of giving birth to and developing new technology. The diverse technical disciplines and the capability of these labs are critical to the solution of many technological energy problems.
- *Systems analysis and engineering*
  Analyzing complex scientific and technological problems, involving many interrelated factors, and then engineering and implementing solutions which guarantee the desired result is a capability for which the aerospace industry is renowned . . .

Here is an overview of the aerospace industry's "energy mission."

SOLAR TECHNOLOGIES

Aerospace companies have become leaders in developing a variety of solar technologies. Some of these technologies are:

Photovoltaics

For almost twenty years, arrays of photovoltaic cells have been used to provide electrical power for satellites and other spacecraft. The ability of these simple semiconductor devices to convert incident sunlight directly to electricity makes them ideal solutions to the problem of providing reliable, long term electrical power with a minimum weight penalty. Aerospace companies working with NASA pioneered their development and continue to improve the technology. Current efforts focusing on increasing their energy conversion efficiency and reducing manufacturing costs may make solar cells cost competitive for a wide variety of small and large scale electrical needs.

Solar Thermal Electric

The solar thermal concept entails using the energy of the sun to heat fluids which drive electricity generating machinery such as turbines, or which provide heat for energy intensive industrial processes. The technical or engineering feasibility of such systems should be proven in several DoE sponsored experimental projects. One of these, a solar power tower concept developed by aerospace companies, employs computer controlled sun-tracking mirrors to concentrate heat onto a central receiver/boiler, the power "tower." The resulting steam drives a turbine to produce electricity. The pilot plant, to be completed in 1981, will generate 10 megawatts of power and will be the world's largest application of solar thermal technology in which electrical energy is produced for the utilities. Aerospace contractors have been selected for design and construction of the collector mirrors and for system management of the program.

Another project employs large hemispherical bowl-like distributed collectors to provide steam for electrical generators. The goal is construction of a five megawatt plant in the mid 1980's. Aerospace companies are also engaged in the development of these solar collector systems.

Solar Heating and Cooling

High altitude air travel and space travel posed difficult problems for aerospace engineers responsible for providing safe and comfortable cabin environments for passengers and crew. Skills gained in solving these environmental problems, combined with skills in development and use of advanced materials, thermodynamic design, systems inte-

Representative of aerospace industry work on wind energy systems is the world's largest "windmill," which recently went into operation at Boone, North Carolina. Developed by General Electric Company's Space Division, the system converts wind force to electricity and feeds two million watts—enough to meet the needs of several hundred homes—into the local power grid. The modern windmill is part of a DoE/NASA wind energy technology program in which The Boeing Company, Grumman Corporation, Lockheed Corporation, Rockwell International, and Westinghouse Electric Corporation are also participating.

The barge-mounted system shown is a first-of-its-kind power plant operating on the Ocean Thermal Energy Conversion (OTEC) concept of using the solar energy stored in warm surface waters to generate electricity. The Mini-OTEC system, developed by Lockheed Missiles & Space Company, has operated successfully since mid-summer at a site off the island of Hawaii. Intended only as a small-scale concept demonstrator, Mini-OTEC generates only 50,000 watts, but larger and more advances OTEC plants could meet the electricity needs of a population of 200,000.

ENERGY

Under construction near Barstow, California is "Solar One," an experimental solar-powered electric generating facility designed by McDonnell Douglas Astronautics Company. The system employs a field of some 2,000 sun-tracking mirrors which reflect solar heat to the central receiver shown; the receiver is a boiler which produces steam to drive an electricity-generating turbine. Solar One is designed to generate 10 million watts, enough to serve a community of 7,000 people. McDonnell Douglas Astronautics is design integrator for the DoE project; Rocketdyne division of Rockwell International is a major subcontractor.

The fuel cell powerplant, long used by NASA to provide spacecraft electrical power, is finding new utility as a pollution-free source of electricity for consumer use. Among a number of fuel cell development programs is the one shown in artist's concept—a multi-module system capable of generating almost five million watts of electricity. Developed by Power Systems Division of United Technologies, it will go into operation next year on the Consolidated Edison grid in lower Manhattan.

gration and other areas of aerospace expertise are enabling aerospace firms to make a significant contribution to solar heating and cooling technology. All buildings—residential, commercial and industrial—are potential markets. High efficiency solar collectors, advanced solar heat pumps, and innovative "total systems" are being developed by aerospace companies, either independently of for DoE.

Wind Power

The key component for transforming wind energy into more useful forms, such as mechanical power or electricity, is the aerodynamic rotor. . . . Wind power systems under development by aerospace companies incorporate rotors from 25 to 300 feet in diameter, and are capable of producing from a few kilowatts to thousands of kilowatts.

Solar Power Satellite

One of the most daring and challenging concepts proposed as a means of capturing vast amounts of solar energy is the Solar Power Satellite (SPS) system. These satellites, possibly 50 square kilometers in size, would be put into geosynchronous orbit, 35,800 kilometers high, where they would convert solar energy to electricity and beam it to earth via microwaves for distribution to electrical utility grids. Recognizing the potential of this system, NASA and DoE are spending $15.6 million jointly to evaluate the feasibility of the concept, assess its economic practicability and its environmental acceptability. The reference system satellite now being studied would provide 5,000 megawatts of power. Final recommendations of the program are due in June 1980.

Ocean Thermal Energy Conversion (OTEC)

Aerospace companies working with the National Science Foundation were the first to evaluate the feasibility of large scale OTEC systems and continue to be the leading designers and prime candidates for fabrication of OTEC pilot plants for DoE. . . . Huge exchangers are required to extract heat from the sun-warmed uppermost levels of the ocean for boiling a highly volatile liquid whose vapor will drive an electricity generating turbine. A unique combination of skills is required to design and integrate the exchangers into a practical system: systems management and large hardware know-how capability, special materials technology, thermodynamics and structural analysis capabilities, experience in solving marine bio-fouling problems and designing deep submersible vehicles. DoE, therefore, is relying on the aerospace industry to develop the first working OTEC systems.

Ocean Kinetic Energy

The kinetic energy of ocean waves and tides is another potential source of nearly limitless energy. . . . Improved energy storage techniques are needed to make tidal systems economical. Several aerospace companies are pursuing research in these areas.

FUSION TECHNOLOGY

Harnessing the nuclear fusion process—the basic energy producing reaction of the sun and also the hydrogen bomb—would give mankind a virtually unlimited, clean source of energy. The fuels deuterium and tritium are available from sea water. Unlike the fission process, fusion produces little radioactive waste. The feasibility of sustaining fusion for production of commercial power is only now being tested in the laboratory. If an experimental fusion reactor can be developed in the 1980's which produces more energy than is put in, DoE says, a demonstration power plant could be running before the end of the 1990's . . .

As contractors for design and development of reactors, and their subsystems, aerospace firms are applying their advanced technology experience in plasma physics, extremely high temperature-high strength materials, cryogenics, super-conducting magnets and overall systems analysis and engineering to help harness fusion power for practical use.

COAL TECHNOLOGIES

Several innovative coal technologies are being investigated by aerospace firms.

Magnetohydrodynamics

One of the promising technologies for extracting electrical energy from coal is magnetohydrodynamics (MHD). MHD devices generate electricity directly from a very high temperature ionized gas produced by burning coal combined with a "seed" material such as potassium. Waste heat from this process can be used to drive a turbine generator, thereby producing additional electricity from the same coal. MHD systems have the potential of producing 50 percent more electricity from the same amount of coal than conventional coal fired utility plants, with greatly reduced sulfur emissions . . .

Several aerospace companies are engaged in pioneering developments in this technology. Their experience with extremely high temperature, heat resistant materials, superconducting magnets and overall systems integration makes them well qualified.

Coal Gasification and Liquifaction

Although coal gasification and liquifaction are prinicipally the province of traditional energy companies, several aerospace companies are working either independently or with DoE to demonstrate the feasibility of deriving both low and high BTU gas and synthetic liquid fuel from coal. One project, based on liquid rocket technology developed for the space program, involves the construction of an experimental facility which will convert 100 tons of coal a day into high BTU pipeline quality gas.

FUEL CELL TECHNOLOGY

Chemical fuel cells were put to use by aerospace engineers during the 1960's to supply spacecraft power. Today, cells small enough to supply a small apartment house and large enough to supplement a metropolitan utility grid are within the state-of-the-art. . . . Today's fuel cells can be made to operate on a variety of conventional fuels, such as natural gas, propane, diesel oil or processed coal, extracting energy from these sources more cleanly and efficiently than conventional powerplants. One aerospace company with extensive experience in developing fuel cells has provided a 4.8 megawatt unit to a New York utility to supplement Manhattan's electrical supply. Other utilities are also ordering multi-megawatt fuel cells to meet part of their electrical demands.

CONSERVATION

Some areas where aerospace companies are active in energy conservation include:

Energy Management

Aerospace companies are designing and marketing computer controlled energy management systems. These systems automatically control heating and air conditioning systems and other high energy consumption equipment in industrial plants and commercial buildings so as to maximize total energy conservation.

Energy Conversion

Several companies are involved in the effort to increase the efficiency of fossil fuel power plants. Waste heat recycling systems and more efficient industrial gas turbines based on aerospace technology are being developed. Advanced research on the combustion process may lead to a broader range of useable fossil fuels, such as powdered coal or residual fuels, for power generation.

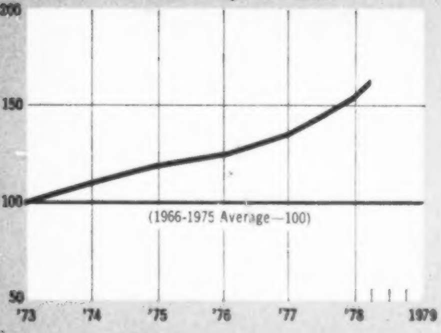
Energy Storage

Compact, high power electrical batteries are required for space missions. Automobiles and small industrial vehicles are now being built, combining such batteries with fly wheel energy storage devices. An entire panoply of potential storage systems like these is emerging from aerospace research.

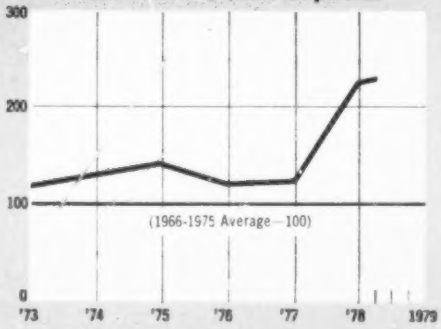
AEROSPACE ECONOMIC INDICATORS

CURRENT

Total Aerospace Sales

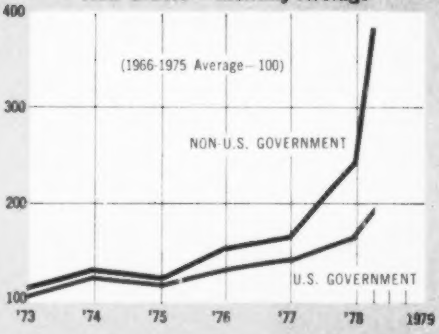


Value of Civil Aircraft Shipments



OUTLOOK

New Orders — Monthly Average

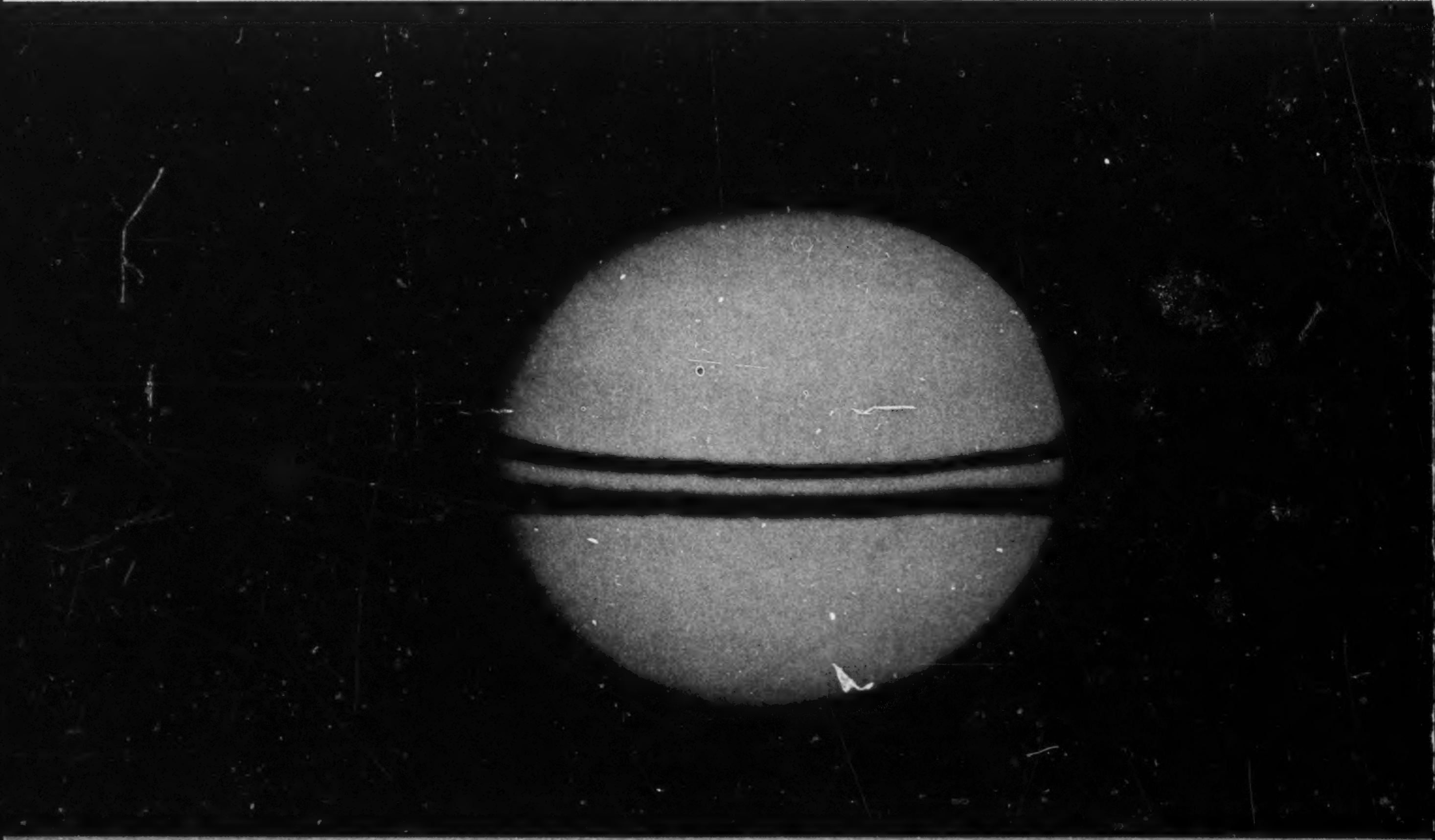


ITEM	UNIT	PERIOD	AVERAGE 1966-1975 *	SAME PERIOD YEAR AGO	PRECEDING PERIOD†	LATEST PERIOD 1st QTR. 1979
AEROSPACE SALES: TOTAL	**Billion $**	**Annually**	**26.6**	**34.1**	**37.5**	39.7
	Billion $	**Quarterly**	**6.4**	**8.5**	**10.3**	10.7
AEROSPACE SALES: TOTAL	***Billion $***	***Annually***	***27.3***	***23.2***	***24.0***	*24.*
(In Constant Dollars, 1972=100)	***Billion $***	***Quarterly***	***6.9***	***5.8***	***6.6***	*6.7*
AEROSPACE PRIME CONTRACT						
AWARDS: TOTAL	**Billion $**	**Quarterly**	**5.8**	**10.1**	**15.5**	15.9
U.S. Government	**Billion $**	**Quarterly**	**4.1**	**5.6**	**8.4**	7.5
Other Customers	**Billion $**	**Quarterly**	**1.7**	**4.5**	**7.1**	8.4
BACKLOG (Major Aerospace Mfgrs): TOTAL	**Billion $**	**Quarterly**	**28.6**	**47.6**	**56.9**	63.0
U.S. Government	**Billion $**	**Quarterly**	**15.9**	**26.6**	**30.1**	32.0
Nongovernment	**Billion $**	**Quarterly**	**12.7**	**21.0**	**26.8**	31.0
DEPARTMENT OF DEFENSE						
Aerospace Obligations: TOTAL	**Million $**	**Quarterly**	**2,712**	**3,123**	**4,528**	3,828
Aircraft Procurement	**Million $**	**Quarterly**	**1,986**	**2,638**	**3,782**	3,194
Missiles Procurement	**Million $**	**Quarterly**	**726**	**485**	**746**	634
Aerospace Outlays: TOTAL	**Million $**	**Quarterly**	**2,405**	**2,045**	**2,500**	2,514
Aircraft Procurement	**Million $**	**Quarterly**	**1,741**	**1,672**	**2,002**	2,025
Missiles Procurement	**Million $**	**Quarterly**	**664**	**373**	**498**	489
NASA RESEARCH AND DEVELOPMENT						
Obligations	**Million $**	**Quarterly**	**780**	**874**	**1,107**	977
Expenditures	**Million $**	**Quarterly**	**789**	**776**	**731**	850
EXPORTS						
Total (Including Military)	**Million $**	**Quarterly**	**1,038**	**1,830**	**3,227**	2,899
New Commercial Transports	**Million $**	**Quarterly**	**345**	**316**	**1,166**	1,195
EMPLOYMENT: TOTAL	**Thousands**	**End of Quarter**	**1,166**	**925**	**1,031**	1,064
Aircraft	**Thousands**	**End of Quarter**	**650**	**501**	**572**	592
Missiles & Space	**Thousands**	**End of Quarter**	**114**	**82**	**84**	86
AVERAGE HOURLY EARNINGS, PRODUCTION WORKERS	**Dollars**	**End of Quarter**	**4.38**	**7.29**	**7.94**	7.98
PROFITS						
Aerospace — Based on Sales	**Percent**	**Quarterly**	**2.7**	**4.1**	**5.1**	4.7
All Manufacturing — Based on Sales	**Percent**	**Quarterly**	**4.8**	**4.7**	**5.6**	5.6

* 1966-1975 average is computed by dividing total year data by 4 to yield quarterly averages.
† Preceding period refers to quarter preceding latest period shown.

Source: Aerospace Industries Association

AEROSPACE INDUSTRIES ASSOCIATION
1725 De Sales St., N.W., Washington, D.C. 20036



Saturn, as viewed by NASA's Pioneer 11. *(See 1979: Planet Year, page 10.)*

MANUFACTURING MEMBERS

- Abex Corporation
- Aerojet-General Corporation
- Aeronca, Inc.
- Avco Corporation
- The Bendix Corporation
- The Boeing Company
- CCI Corporation
  - The Marquardt Company
- Chandler Evans, Inc.
  - Control Systems Division of Colt Industries Inc.
- E-Systems, Inc.
- The Garrett Corporation
- Gates Learjet Corporation
- General Dynamics Corporation
- General Electric Company
- General Motors Corporation
  - Detroit Diesel Allison Division
- The BFGoodrich Company
  - Engineered Systems Division
- Goodyear Aerospace Corporation
- Gould Inc.
- Grumman Corporation
- Heath Tecna Corporation
- Hercules Incorporated
- Honeywell Inc.
- Howmet Turbine Components Corp.
- Hughes Aircraft Company
- IBM Corporation
  - Federal Systems Division
- ITT Telecommunications & Electronics Group-North America
  - ITT Aerospace/Optical Division
  - ITT Avionics Division
  - ITT Defense Communications Division
- Lear Siegler, Inc.
- Lockheed Corporation
- Martin Marietta Aerospace
- McDonnell Douglas Corp.
- Menasco Inc.
- Northrop Corporation
- Parker Hannifin Corporation
- Pneumo Corporation
  - Cleveland Pneumatic Co.
  - National Water Lift Co.
- Raytheon Company
- RCA Corporation
- Rockwell International Corporation
- Rohr Industries, Inc.
- The Singer Company
- Sperry Rand Corporation
- Sundstrand Corporation
  - Sundstrand Advanced Technology Group
- Teledyne CAE
- Textron Inc.
  - Bell Aerospace Textron
  - Bell Helicopter Textron
  - Dalmo Victor Operations
  - Hydraulic Research
- Thiokol Corporation
- TRW Inc.
- United Technologies Corporation
- Vought Corporation
- Western Gear Corporation
- Westinghouse Electric Corp.
  - Public Systems Company

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OFFICIAL PUBLICATION OF THE AEROSPACE INDUSTRIES ASSOCIATION • WINTER 1980

A 0250-1

Aerospace Review and Forecast 1979/80

aerospace perspectives

Arthur F. Burns, *former chairman of the Federal Reserve Board, before the annual meeting of the International Monetary Fund and The World Bank in Belgrade, Yugoslavia:*

"The precise therapy that can serve a nation best is not easy to identify, and what may work well in one country may work poorly in another. In the case of the American inflation, which has become a major threat to the well-being of much of the world as well as of the American people, it would seem wise to me at this juncture of history for the government to adopt a basic program consisting of four parts.

"The first of these would be a legislative revision of the federal budgetary process that would make it more difficult to run budget deficits and that would serve as the initial step toward a constitutional amendment directed to the same end. The second part would be a commitment to a comprehensive plan for dismantling regulations that have been impeding the competitive process and for modifying others that have been running up costs and prices unnecessarily. The third part would be a binding endorsement of restrictive monetary policies until the rate of inflation has become substantially lower.

"And the fourth part would consist of legislation scheduling reductions of business taxes in each of the next five years—the reduction to be quite small in the first two years but to become substantial in later years. This sort of tax legislation would release powerful forces to improve the nation's productivity and thereby exert downward pressure on prices; and it would also help in the more immediate future to ease the difficult adjustments forced on many businesses and their employees by adoption of the first three parts of the suggested program."

Clare Boothe Luce, *at the U.S. Military Academy, West Point, New York, where she was presented the Sylvanus Thayer Award:*

"We seem to have entered that period which history tells us always marks the hour of greatest danger to a democracy. This is when its citizens persist in raiding their own treasury, and, when faced with a strong and avowed enemy . . . they substitute the ideal of peace for the idea of national security. It is then that a democracy is doomed to depression and defeat unless it is rescued from the follies of its unthinking majority by those thinking minorities which Thomas Jefferson called 'The natural aristocracies of brains and talent' . . .

"It is certainly arguable that the conquest of the U.S. by force of arms is not likely in this century. For even if our military position grows considerably weaker, we would still retain a fearsome nuclear second-punch capacity. What now seems more likely to happen is the collapse of our industrial system, which is today not only inflation ridden but is over 50 percent dependent on Middle East oil. The truly shameful and humiliating fact is that six years after the Arab oil embargo, our government still has no realistic policy—political or military—for securing our access to Arab oil in the amounts, no less at the prices, necessary to maintain the productivity of our economy."

T. A. Wilson, *chairman of the board and chief executive officer, The Boeing Company, in an address at the Wright Memorial Dinner in Washington, D.C., following his acceptance of the Wright Memorial Trophy:*

"Our present energy situation is largely due to our past mistakes. After the 1973 oil embargo we had price controls on domestic oil, even though the price of foreign crude was rising rapidly. This had a chilling effect on domestic oil production but helped keep consumption at a high level. As a result, we've become used to a steady supply of underpriced fuel. Had the free market system been allowed to work during the past six years, U.S. consumption might have declined on a steady and predictable basis as worldwide petroleum prices went up. . .

"In the final analysis, economics will determine how we solve our energy problems. There will be a supply of *expensive* petroleum out there for the balance of this century, but we should be developing alternate energy sources while we can do so on a well-planned, cost-effective basis. There are no easy solutions to energy problems. Increased costs and periodic shortages in the near term will require some painful adjustments in our life styles, but, in the long term, I am optimistic. We have the technological resources to create a new energy base if we just put our know-how to work."

Thomas A. Murphy, *chairman, General Motors Corporation, at the Greater Detroit/Michigan State University Management Conference, Troy, Michigan:*

"Make no mistake—America needs nuclear energy. We need those plants still to be built and we need those plants already providing 12 percent of our electricity nationally and as much as 50 percent in some sections of the Midwest and Northeast. We have the knowledge, the necessary technology, and the experience to operate them safely. . .

"There are risks involved in nuclear generation; no one denies that. But they are controllable risks . . . When electricity was first offered for home use several generations ago, there were similar fears of risk. In fact, after World War II, some farmers in outlying areas looked with suspicion on all those high-voltage wires being strung across their land by REA co-ops. They feared that so much energy compressed in such a tiny space would surely burst and explode someday—and we'd all be consumed in a fiery holocaust.

"This is not too far removed from the perception that the American public is being sold be many of our 'No-Nukes' militants. In my opinion, the oversimplified slogans they parade through the streets are a cynical affront to the intelligence of a democratic and self-determining people. I will go even further. I find a disturbing parallel between such tactics and those acts of political terrorists. To reduce one of our nation's—and the world's—most complex and urgent problems to misleading slogans, and to use fear of the unknown as a callous substitute for reason, is a form of ideological terrorism. And I abhor it just as much as I do physical terrorism."

AIA

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The purpose of AEROSPACE is to:

Foster understanding of the aerospace industry's role in insuring our national security through design, development and production of advanced weapon systems.

Foster understanding of the aerospace industry's responsibilities in the space exploration program.

Foster understanding of civil aviation as a prime factor in domestic and international travel and trade.

Foster understanding of the aerospace industry's capabilities to apply its techniques of systems analysis and management to solve local and national problems in social and economic fields.

AEROSPACE is published by the Aerospace Industries Association of America, Inc., the national trade association of the designers, developers and manufacturers of aircraft, missiles, spacecraft, their propulsion, navigation and guidance systems and other aeronautical systems and their components.

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The 'Uncertainty' Factor

BY KARL G. HARR, JR.
President, Aerospace Industries Association

The U.S. aerospace industry begins the new decade with a substantial backlog of orders, improved financial health and prospects for increased activity in the 1980s. The bright outlook, however, is based on current statistics and predictable trends. Our optimism must be tempered by the realization that the industry's future—and that of all American industries—is inextricably linked to unpredictable political, social and economic developments in a rapidly changing world. Such developments may present new opportunities, but they seem more likely to engender new difficulties. Thus, we must qualify our projections by applying an "uncertainty" factor.

Assurance of adequate energy supplies ranks high on any list of uncertainties. There is no need to elaborate on the implications to industry of further energy supply disruptions. This area is one which suggests opportunity as well as problems, since the high technology expertise of the aerospace industry can be—in fact, is already being—applied to advantage in the national quest for alternative energy sources.

A related matter is the supply of other materials critical to aerospace manufacturing operations. Since we are dependent on foreign sources for some such materials, there looms the possibility that we might have to face a situation analogous to the oil problem, wherein uncontrollable political developments outside the U.S. could jeopardize our supply.

Another matter of concern is growing foreign competition. The world aerospace market is larger than ever, but there is question as to what share of it American manufacturers will be able to realize. The European aerospace industry, bolstered by the backing of its various governments, is providing strong competition and we look for accelerated effort from that quarter. The Japanese aerospace capability has so far been of modest order, but the appeal of the very large market may prompt upgraded capability, heightening an already intense degree of world competition.

We anticipate escalation of the trend wherein Third World countries are seeking greater control over "global" resources. These nations have been effectively promoting the premise that the world's extraterritorial resources belong to the world at large. They suggest that, in exchange for access to these resources, industrialized nations should share resultant benefits and transfer to international control the technology involved in utilizing the resources. Whether this concept will be incorporated in international law remains to be seen, but the possibility is disturbing. It has broad implications for the industries of the developed nations.

Finally, there is America's defense posture and its ability to respond to challenge in an increasingly restive world, a matter of paramount importance not only to our own security and economy, but to the continuation of civilized world order. Events in Iran and Afghanistan have understandably intensified fear and uncertainty. On the other hand, the reaction of the American people to such events has been heartening. There is growing support for increased U.S. defense effort and there are clear indications of a strengthened national will to resist outrage and aggression. Thus, there is reason to hope for a real resurgence of national unity, an optimistic note on which to begin a new decade.

Aerospace Review and Forecast 1979/80

The aerospace industry closed out the decade of the seventies on a high note. Although statistical data will undergo refinement in coming months, preliminary estimates for 1979 show new peaks in sales, backlog, earnings, exports and contribution to the U.S. balance of trade.

Here are the highlights:

- Total industry sales amounted to $45.5 billion, an increase of some $8 billion over the preceding year. The sales figure represents an all-time statistical high, but it is distorted by the effects of the nation's exceptionally high inflation rate during the year. Nonetheless, 1979 sales volume amounts to an increase of more than 20 percent over 1978, so the gain outstripped the inflation rate by a generous margin.

In the interests of perspective, it is the industry's practice to compare each year's sales volume with that of the peak year—1968—by converting to constant dollars. On that basis, 1979 sales constitute roughly three-quarters of the 1968 volume; in constant dollar terms, 1979's $22.7 billion compares with $29 billion in 1968, so the industry is still well below the peak. However, 1979 constant dollar sales are higher than those of any other year in the decade of the seventies.

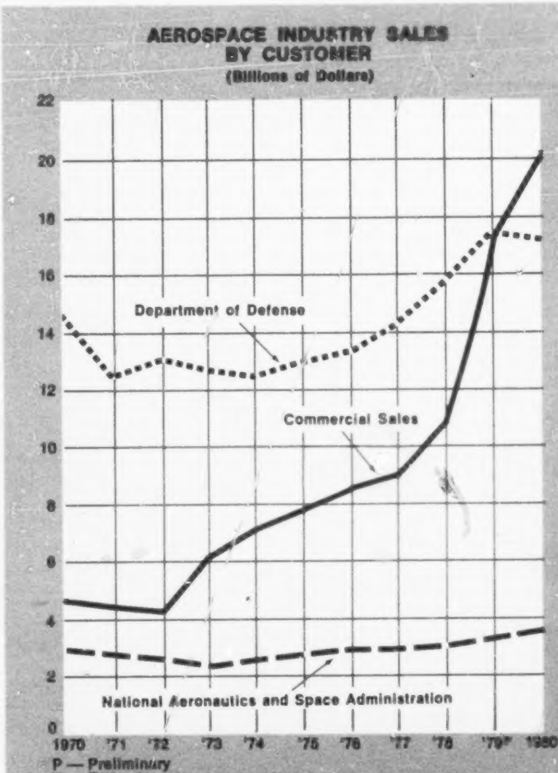
- Backlog at the end of 1979 was $68.4 billion, up about $11.5 billion over the 1978 figure.
- Aerospace exports reached a new record level of $11.6 billion, up about 15 percent over 1978, which was itself a record year. The export volume is remarkable because it was achieved despite a sharp drop—almost $2 billion—in shipments abroad of military equipment. This decline was more than compensated by a big increase—about $3.5 billion—in civil exports.
- At a time when export sales are more important than ever to the U.S. economy, the aerospace industry recorded its highest-ever international trade surplus—more than $10 billion, about $1 billion above 1978, the previous record year.
- Profit after taxes, measured as a percentage of sales, increased from 4.4 percent in 1978 to 5.1 percent in 1979. The aerospace profit rate edged closer to, but remained well below, the average for all U.S. manufacturing corporations, which was 5.8 percent.
- Employment—1,120,000 at year's end—reached its highest level of the decade.
- A matter of particular interest is the fact that, once again, the largest increment of sales gain was in the commercial area, particularly airline transport aircraft. This underlines a significant trend, in evidence throughout the seventies, with regard to the changing aerospace industry business mix. In the first year of the seventies, defense business accounted for about two-thirds of all sales of aerospace products and services; at that time, commercial sales represented only 18 percent. Although the level of military sales increased during the seventies, commercial activity increased at a much more rapid rate, with the result that commercial aerospace sales almost matched defense aerospace volume in 1979. The trend is expected to continue.

In summary, the industry experienced in 1979 a continuation of the ascending trend in its activity curve, which had been relatively flat for most of the seventies, turned upward in 1976/77, then climbed at a higher angle in 1978 and 1979.

FORECAST

The most significant projection for 1980 is that commercial aerospace sales are expected to outstrip sales to the Department of Defense for the first time in the industry's modern history. Sales of aerospace products and services to the commercial sector are estimated [illegible] $20.2 billion in 1980, while DoD sales are expected to drop slightly below the 1979 level to $17.4 billion.

The industry estimates overall 1980 sales at $49.2 billion, which would represent an increase of about eight percent. The total sales figure is compounded of aerospace sales of $41 billion and non-aerospace sales of $8.2 billion. Industry employment is expected to increase only slightly, to 1,131,000.



SALES BY CUSTOMER

In 1980, for the first time in modern history, the aerospace industry is expected to sell more of its aerospace products and services to commercial customers than to the Department of Defense. Commercial aerospace sales in 1980 are estimated at $20.2 billion, compared with $17.4 billion in sales to military customers.

Projections for years beyond 1980 are clouded by a number of uncertainties, but the following is a general view of what the industry sees for the decade of the 1980s:

Defense. The aerospace industry begins the new decade with a substantial backlog of military orders, though one not appreciably higher than it was at the end of 1978. President Carter has announced Administration plans to increase defense funding for the fiscal years 1981-85 to levels averaging 4½ to 5 percent above the rate of inflation. This augurs greater industry defense activity, but not as great as one might expect. Much of the increased funding will go into personnel, operations and maintenance accounts, and a major portion will go for non-aerospace procurement—shipbuilding, for example.

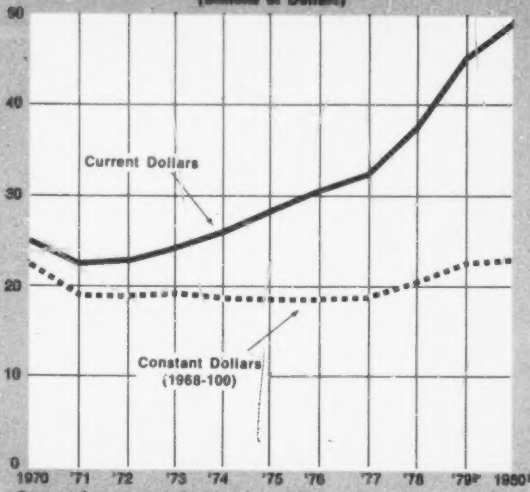
On the basis of stated DoD plans for weapons development and production—for instance, the MX strategic missile system and the family of cruise missiles—the industry anticipates increased workload in the missile area along with long-term production of several relatively new aircraft. On the other hand, production of some major aircraft types is winding down. Generally, if Congressional appropriations support Administration plans, the aerospace industry can expect somewhat higher levels of DoD sales, but the activity gain will not be of dramatic order.

Space. NASA's long-range plans for the era of the Space Transportation System contemplate substantially increased space mission frequencies and payload deliveries, which would involve correspondingly increased industry activity in development and fabrication of space systems. However, Administration projections for space funding in coming years suggest that the space plan will undergo downward revision. The advent of the Space Shuttle and NASA's planned emphasis on pursuing space-derived Earth benefit will offer many opportunities for demonstrating the very real practical benefits, both civil and military, that exploitation of the space medium affords. This could revive public interest in space and bring about higher levels of funding support. Thus, there is a possibility that the industry's space activity will grow in the latter years of the decade, but for the near term space workload should remain at something approximating the current level.

Commercial Sales. The commercial area—particularly production of commercial transport aircraft—offers the greatest potential for expansion of the industry's workload. Projections indicate that world airline traffic will almost double by 1989, creating a very large requirement for new airline aircraft. Additionally, some 3,000 of the 5,000 jet transports in commercial service today are more than nine years old, about 1,500 of them more than 12 years old. The need for greater fuel efficiency and lower maintenance costs dictates replacement of these aging aircraft; also, many of them will be forced into retirement by government regulations. A consensus estimate of the combined new lift/replacement world market for the 1980s is about $100 billion. In addition, civil helicopter production is experiencing extremely rapid growth and is expected to become a more significant portion of the industry's commercial business; the world market for the coming decade is estimated at $10 billion.

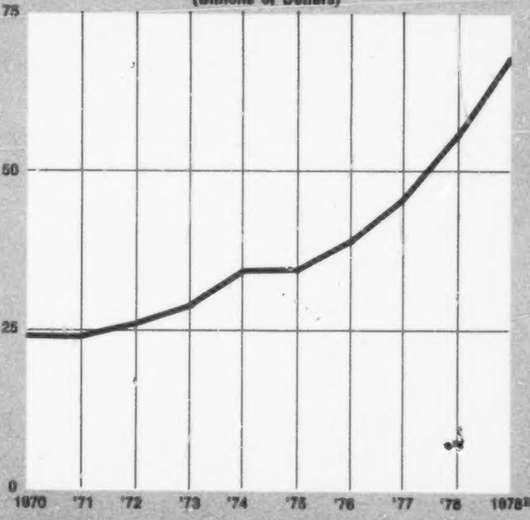
Expectations for expanded commercial activity could be sharply altered by heightened U.S. economic troubles and by further adverse developments in the energy situation. For example, will there be adequate fuel to serve the projected traffic growth? If so, will its cost be so high as to send airline fares beyond affordable limits and thus dramatically reduce passenger demand? There are several other factors which have strong bearing on the airlines' ability to finance needed new airplanes. So the aerospace industry's future level of commercial activity is largely dependent upon whether the airlines will achieve the financial health essential to their re-equipment plans; if they can, the commercial potential for the aerospace industry is greater than at any time in its history.

AEROSPACE INDUSTRY SALES
(Billions of Dollars)



Source: Aerospace Industries Association
P — Preliminary
E — Estimate

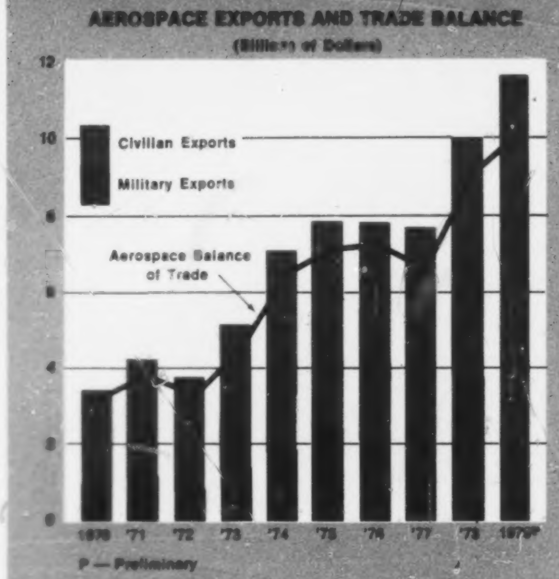
BACKLOG OF MAJOR AEROSPACE COMPANIES
(Billions of Dollars)



E — Estimate

TOTAL SALES AND BACKLOG

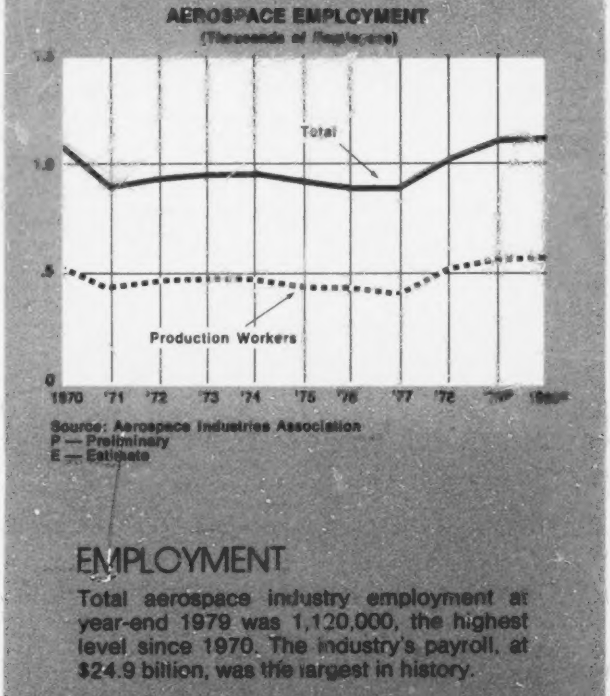
The aerospace industry's total sales in 1979 amounted to $45.5 billion, up some $8 billion over 1978. The 1979 figure is compounded of $38.2 billion in aerospace products and services and $7.3 billion in non-aerospace sales. The total amounts to a statistical record, but in inflation-adjusted terms it is more than $6 billion below the industry's *real* peak year 1968. The industry's backlog at yearend 1979 was $68.4 billion and Aerospace Industries Association predicts total sales of $49.2 billion for 1980. Defense aerospace sales are expected to decline slightly but another large increase in commercial sales is forecast.


AEROSPACE EXPORTS AND TRADE BALANCE
(Billions of Dollars)

P — Preliminary

EXPORTS AND TRADE BALANCE

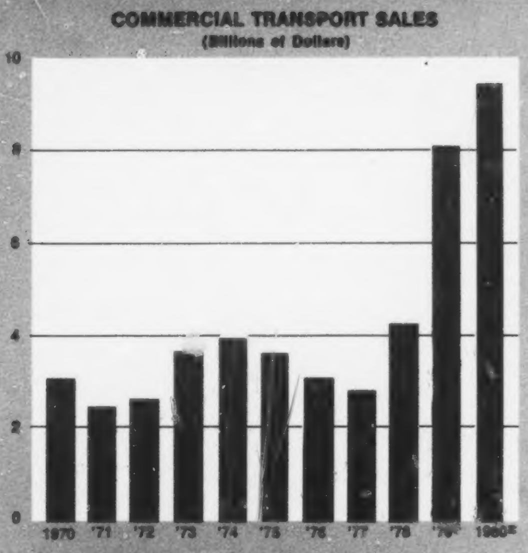
The aerospace industry's performance in export sales reached an all-time high in 1979, as did the industry's contribution to the U.S. balance of trade. Exports totaled $11.6 billion, an increase of more than $1.5 billion over 1978, the previous record year. Aerospace imports increased some $500 million to $1.5 billion. Thus, the aerospace balance of trade was $10.1 billion, once again the major positive factor in U.S. foreign trade.


AEROSPACE EMPLOYMENT
(Thousands of Employees)

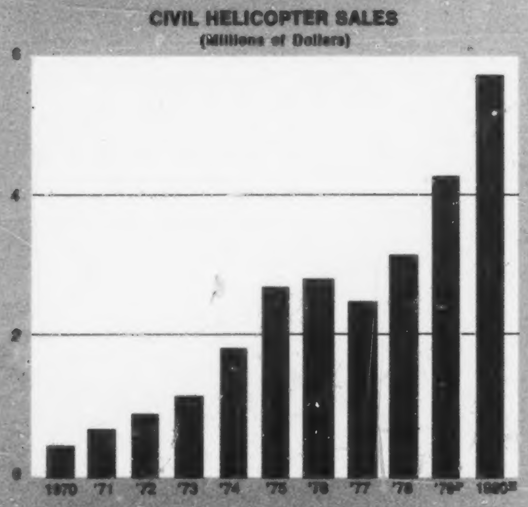
Source: Aerospace Industries Association
P — Preliminary
E — Estimate

EMPLOYMENT

Total aerospace industry employment at year-end 1979 was 1,120,000, the highest level since 1970. The industry's payroll, at $24.9 billion, was the largest in history.


COMMERCIAL TRANSPORT SALES
(Billions of Dollars)

P — Preliminary
E — Estimate


CIVIL HELICOPTER SALES
(Millions of Dollars)

P — Preliminary
E — Estimate

COMMERCIAL SALES

Sales of commercial transport aircraft in 1979 reached a record $8.2 billion, up $3.9 billion over 1978. Aerospace Industries Association forecasts a further increase to $9.5 billion in 1980. Estimate of the world market for new transports in the decade of the 1980s is more than $100 billion.

The steady growth of civil helicopter deliveries continued in 1979, with sales of $436 million, an increase of $110 million or about 33 percent. Sales forscast for 1980 is $580 million and the civil helicopter market for the 1980s is estimated at $10 million.

(Editor's note: **Among the major problems facing American companies is growing competition in world markets from companies owned or heavily subsidized by foreign governments. In the following article, Dr. Michael A. Samuels, executive director for Third World Studies at the Center for Strategic and International Studies of Georgetown University, says that the U.S. government must address inequities this situation creates or U.S. companies and their employees will suffer the consequences. Dr. Samuels' comments originally appeared in *Business America*, a publication of the U.S. Department of Commerce.)**

Competitive Threat To U.S. Companies in Export Markets

State-owned companies abroad pose a growing competitive threat to U.S. companies in export markets. Such companies are not governed by the same rules as are U.S. companies. They are heavily subsidized and supported by their governments. They are also not required to earn profits comparable to those of their privately-owned competitors. They rarely pay dividends, and their losses do not lead to bankruptcy. Even when such firms incur substantial losses, they may offer prices below private U.S. companies in export markets. The government assumes the losses and provides further investment capital directly or through guaranteed low-interest bank loans. State-owned companies further affect foreign private corporate competition by giving preferences in their purchasing to domestic sources.

The size and scope of state-owned companies abroad is increasing each year. This trend is changing the rules of the game of international competition. A few figures and projections can illustrate the picture. By the mid-1980s, companies owned or controlled by government are expected to account for nearly 50 percent of the U.S. chemical industry's competition in export markets for petrochemicals, fertilizers, and plastics; 55 percent of the non-communist world steel production is already owned outright by government. State ownership is already evident in posts, telecommunications, electricity, gas, oil production, aluminum, coal, paper, railroads, airlines, textiles, motor industries, electrical and non-electrical equipment, and shipbuilding. The state has an ownership stake in 19 of Europe's 50 largest industrial companies. Investment in government-owned enterprises is more than 25 percent of all investment in Sweden, 50 percent in Austria, 35 percent in Italy.

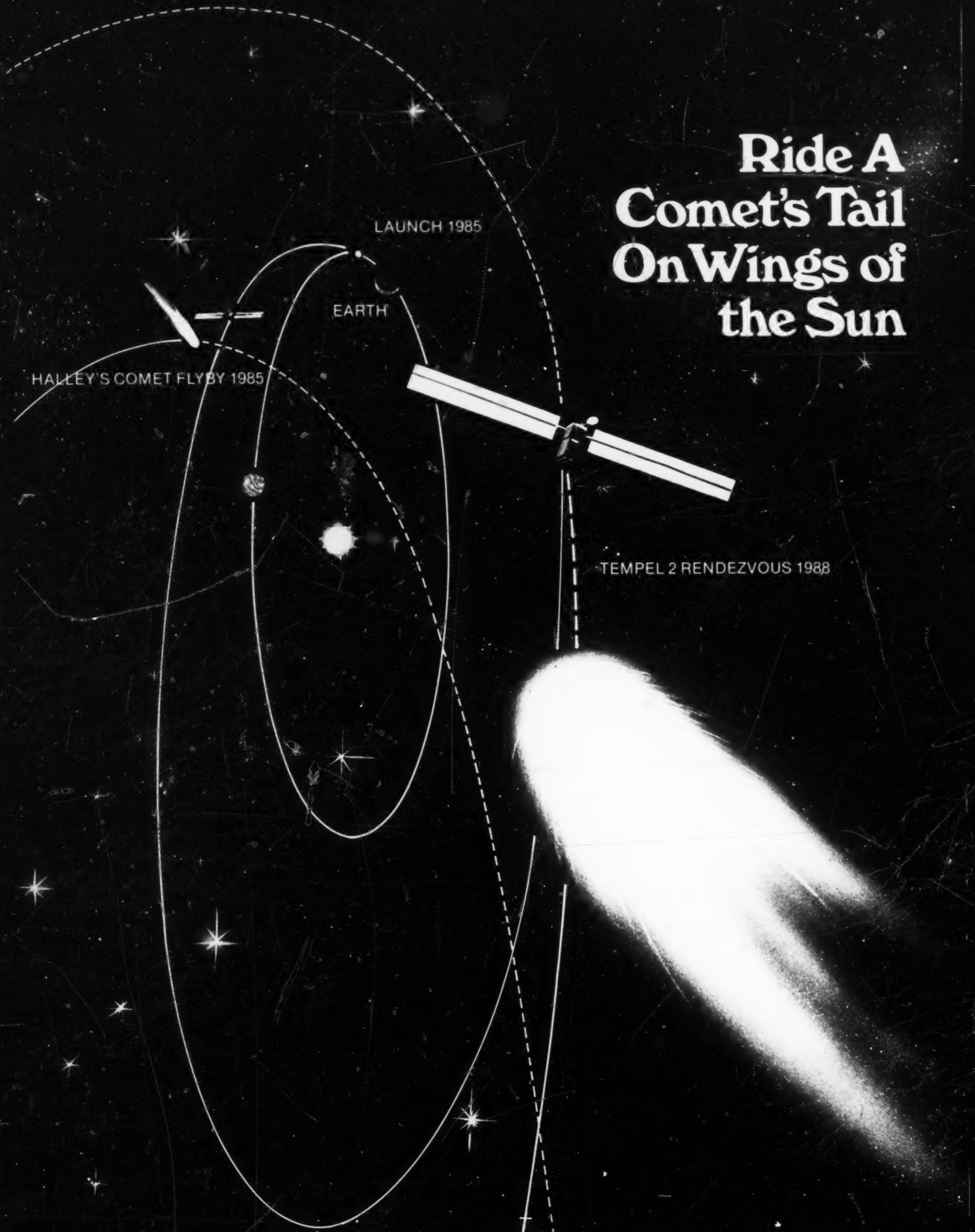
A new wave of government ownership has swept through European industry in the 1970s. There have been many reasons: rescue operations to save employment in sick industries; diversifications to spread the national industrial base; stimulation for internal economic growth; and developing industrial capabilities for high risk ventures shunned by private capital, often involving heavy R & D expenditures. The latter two reasons provide much less dramatic exposure and political reaction than the earlier wave of nationalizations. Government programs include loans, equities and cash grants, equity capital through stock purchases, and direct and indirect assistance in product development in many strategic areas of exporting industries.

More and more export-oriented foreign state enterprises are diversifying. This means that more and more U.S. industries must contend with this new form of state-owned and state-assisted competition. In developing countries as well, the trend is towards a large and growing number of government-owned enterprises whose policies and pricing behavior is not entirely commercially motivated.

The United States today, even after the General Agreement on Tariffs and Trade, continues a policy of "beggar thyself" in foreign trade. We must provide new and better policies and programs to support our exports in competition with state-owned companies. We must move aggressively against the unfair and closed practices of such companies in all markets that adversely affect the U.S. economy. The Industry and Trade Administration of the U.S. Department of Commerce must be provided the mission and resources to study and monitor the scope, behavior, and competitive impact of state-owned companies.

**Reprinted from *Business America*, December 1979,
a publication of the Department of Commerce.**

Ride A Comet's Tail On Wings of the Sun



Spacecraft already have lifted men to the surface of the moon. Space instruments have harvested information from Jupiter, Mercury, Venus, Mars and Saturn.

Now, in their quest to further narrow the gap between the known and the knowable, space scientists are marshalling their expertise to study yet another celestial phenomenon—a comet called Halley. Although the investigation of a comet from a space base is not entirely without precedent—Skylab astronauts photographed Kohoutek six years ago—never before have scientists been afforded this opportunity to study comets close up.

Plans are being laid for a mid-1985 launch of an unmanned spacecraft with instruments designed to unlock some of Halley's secrets before it soars around the sun on its 76-year orbital voyage. In the brief encounter—it's nearly a head-on flyby because the comet's orbit is counter to Earth's—an instrument probe will be released into Halley's coma, the halo of gases and dust surrounding the comet's three-mile wide nucleus. The spacecraft has an additional objective.

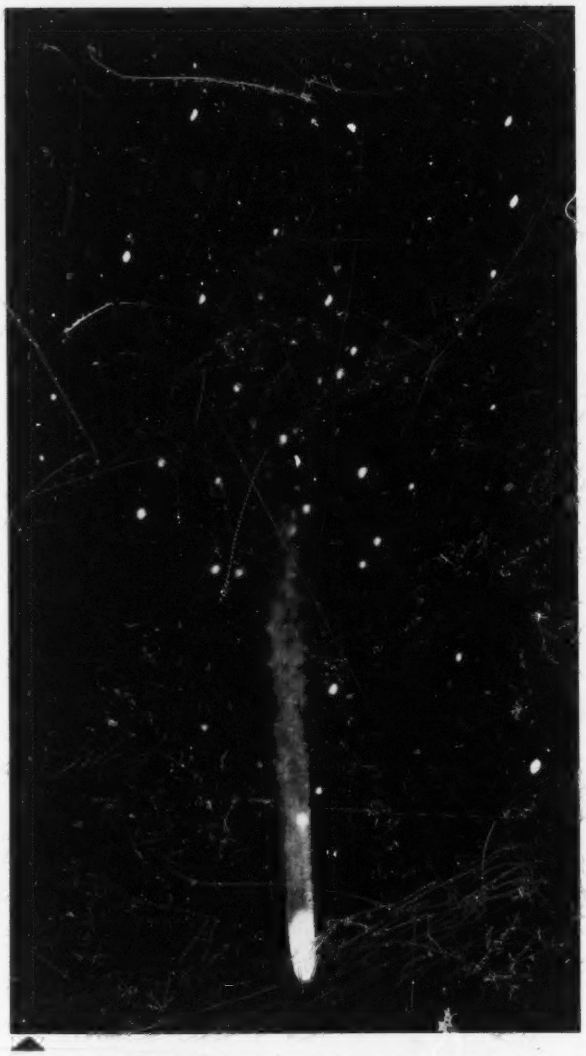
Three years after the Halley flyby, the spacecraft will rendezvous with a smaller, older comet, Tempel 2—coasting alongside it for a year or more, probing its characteristics as the comet curves around the sun and then fades toward the orbit of Jupiter.

Such a two-for-one mission, though still in planning stages, holds several attractions:

- Science gets a chance to see two shows for almost the price of one.
- The comet Halley flyby mission affords a rare opportunity—when it next visits in 2061, few of us will be alive—to see what astronomers call the most spectacular showboat regularly touring the space environment of Earth. Unfortunately, when comet Halley reaches perihelion (its nearest point to the sun) and becomes its brightest on Feb. 9, 1986, it will be hidden from viewers on Earth because it will be on the opposite side of the sun, say the Jet Propulsion Laboratory mission planners. Halley's visit, they say, will be one of the least spectacular shows in several centuries unless the mission brings it down to Earth in living color.
- The Tempel 2 rendezvous particularly excites the scientists who for the first time will get a prolonged, closeup look at a comet throughout most of its dynamic range of activity.

Little is known about comets from direct observation. And nothing from up close. Comets spend most of their lifetimes outside the reach of the most powerful telescopes. Halley's trek, for instance, stretches beyond Neptune's orbit.

But scientific interest in cometary phenomena is spurred on by much more than curiosity. Comet nuclei probably contain samples of the least altered materials present in our solar nebula. Next to the sun, comets may be the most potentially rewarding objects for understanding the origin of the solar system. Unlike most other extraterrestrial bodies, comets appear relatively undisturbed by tectonic activity or the meteoric bombardment that wipes away clues to their origin.



This photo of Halley's Comet was taken by Lowell Observatory in 1910 when the comet last approached Earth. The original black-and-white photo was computer-enhanced and colored by The Kitt Peak National Observatory, operated by the Association of Universities for Research in Astronomy, Inc.

Moreover, scientists hope to discover much about comets themselves by comparing information from two dissimilar comets, Halley and Tempel 2. From the mission they hope to determine their chemical compositions and gain some insight into an especially nagging riddle: the activity that takes place within a comet's ion tail. According to one astronomer, complex structures within the ion tail—whorls and knots and helices—appear to accelerate very rapidly away from the comet head. Some plasma physicists conjecture that this activity is related to solar wind interactions, but these interactions are not fully understood.

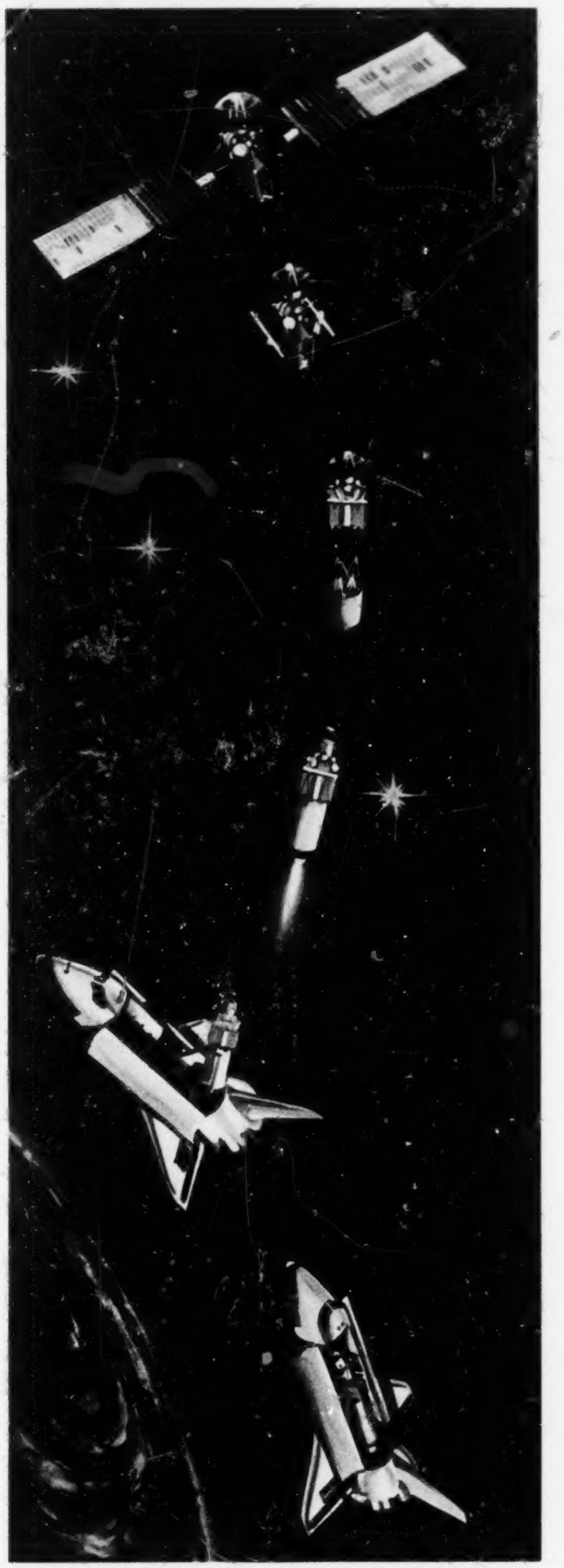
Advanced space technology is gradually enabling scientists to convert conjecture to fact. They now have a way to get there—to build a craft to conduct a four-year, 1.1 billion mile journey—to pursue a dual cometary investigation.

None of it would be possible without solar electric propulsion systems that use the sun's energy to generate and accelerate ions.

Present day deep-space mission designs revolve around the ion engine technology pioneered by Hughes Aircraft Company, where it has been pursued for 20 years.

Ion engines don't appear very formidable. They are no larger than a snare drum and too weak to push a walnut uphill. For the comet mission, ion thrusters with only 2,500 pounds of propellant will barely nudge the 8,000-pound craft along by exerting an average thrust of 0.06 pounds. Certainly not much force. Definitely not much acceleration.

But they have one overriding advantage over heavyweight chemical engines with tremendous bursts of power. Ion engines work a long time—years, in fact—on very little propellant. They are more efficient because of the high exhaust velocity of ions, charged particles created by electron bombardment and electrostatically accelerated before being squirted out the spacecraft's tail, providing forward thrust.



A scientific mission to comets Halley and Tempel 2 could mark a turning point for America's space exploration. Besides signaling a shift from powerful chemical propulsion systems to low-thrust but efficient ion engines, the mission could introduce the concept of multi-purpose design and engineering for many deep space ventures—possibly including a 1986 solar probe, a Saturn orbiter-probe in '87 and such 1988 plans as rendezvous with asteroids and a Mercury orbiter. Integral to the multi-mission design and engineering concept is the idea of staged propulsion: a Space Shuttle initially planting the spacecraft in Earth orbit, an inertial upper stage boosting it out of Earth orbit and a cluster of eight ion engines (a maximum of six in operation simultaneously) nudging the scientific payload within range of the two comets. Solar array wings spanning 105 feet would provide power for ionization and ion acceleration in the final stage, a solar electric propulsion system.

Theoretically, for every second the Halley-Tempel 2 mission's six ion engines work in unison at maximum thrust (0.18 lb.), they would produce a gain in speed of 0.225 millimeter per second. That fraction of a millimeter would go a long way—45 miles per hour added every day, 16,425 mph a year!

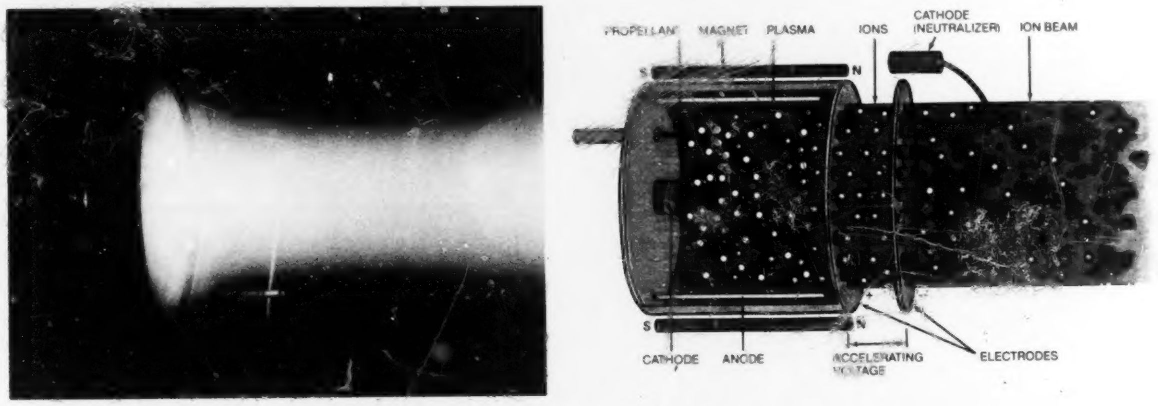
In actuality, speed gains won't be near that because the ship moves away from the sun. Which leads to the ion engine's main disadvantage: relatively large power requirements for ionization and ion acceleration. A Halley-Tempel 2 mission spacecraft would require about 32 kilowatts of electric power, 18.2 kilowatts for ion propulsion alone.

To solve the power source problem, engineers plan to capture the power of the sun. Two giant wings will unfold from the spacecraft like venetian blinds; the wings will be garnished with solar arrays to collect the sun's energy and convert it to electricity. Of course, as the spacecraft tracks Tempel 2 away from the sun, its ion thrusters must throttle down to match dwindling solar power.

But before that happens, earthbound scientists would be able to vicariously ride a comet's tail on wings of solar power. That power source creates an electrostatic field where highly excited electrons bombard electrically neutral mercury atoms. The electron bombardment knocks off the atoms' outermost electrons, causing the atoms to be ionized or electrically charged. The flood of freed electrons, mercury atoms and ions forms a plasma—or a very dense, energized gas cloud—of randomly moving neutral and charged particles. Another more powerful electric field accelerates the charged particles and focuses them through 15,000 tiny exhaust apertures. The exhaust velocity of these ion beams exceeds 100,000 miles per hour.

This remarkable exhaust velocity makes the ion engine up to 100 times more efficient than chemical engines, whose fuel requirements would pinch a deep space scientific payload onto the head of a pin. For the tentative Halley-Tempel 2 mission, JPL wants to assemble a 2100-pound scientific payload carrying about 265 pounds of scientific instrumentation plus a 500-pound Halley probe. JPL plans to ask space scientists to propose projects that could help answer some of the most crucial questions about comets and cosmology.

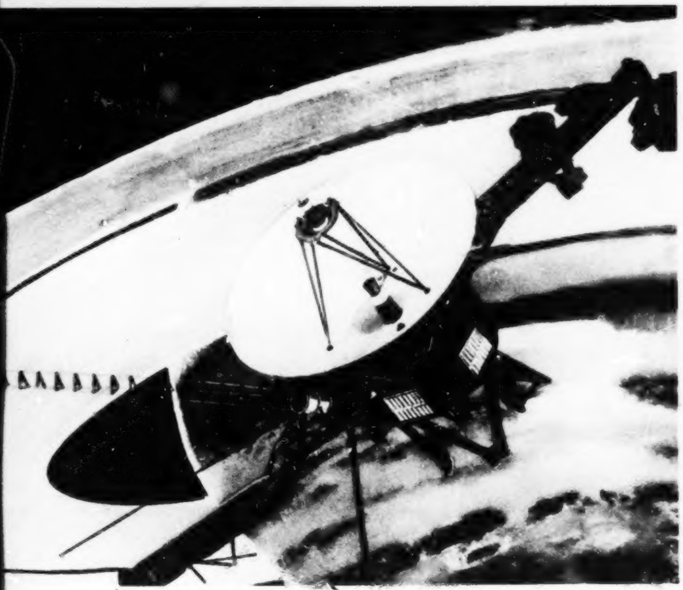
In a few years Halley's Comet will again arouse Earth's emotions. But this time, we'd go out and meet it—perhaps learning more in this brief encounter about the comet's character than man has learned since the beginning of recorded history.



▲ Tests are under way to evaluate performance over 15,000 hours of operating ion engines, left. Drawing on right shows how ion engines work. Ions, or electrically charged atomic particles, are created when fast-moving electrons bombard vaporized mercury atoms, knocking off their outermost electrons. The cathode, which emits the electrons, and the anode lining the chamber set up a 35-volt electric potential that energizes the electrons. A magnetic field within the chamber keeps the electrons from traveling directly to the anode, affording maximum atomic contact. The atoms, ions and electrons form a plasma, a dense gas of neutral and charged particles. To extract the positive-charged ions and accelerate them as they are focused through tiny exhaust apertures, another more powerful electric potential of 1,000 volts is applied to the electrodes. The negative electrode attracts the positive-charged ions and ejects them through the electrode's apertures. Ultimately, the exhausted ion beams become neutralized by recombination with electrons emitted by an external cathode. Otherwise, the ions would be attracted back to the spacecraft surface, negating the ion thrust.

Reprinted from VECTORS, a publication of Hughes Aircraft Company.

Aerospace Highlights: 1979



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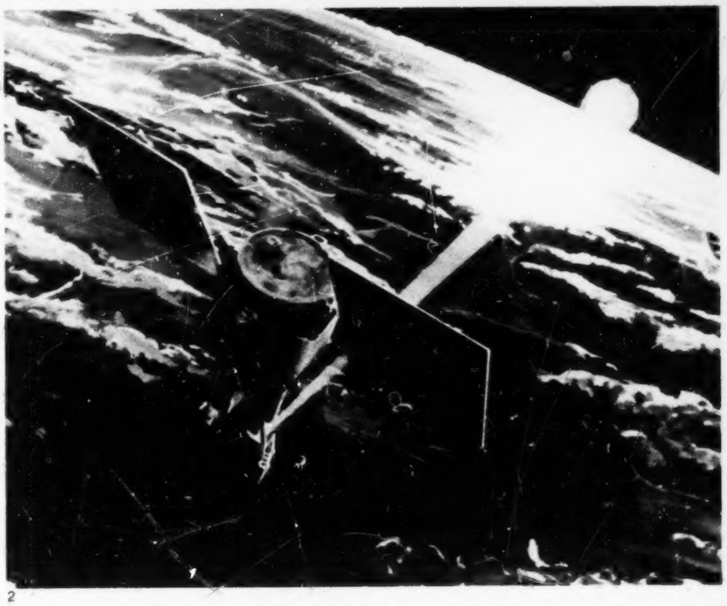

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Space

For the National Aeronautics and Space Administration, 1979 was the "Year of the Planets," as several spacecraft sent back to Earth unprecedented levels of data on Venus, Mars, Jupiter and Saturn. The year's major planetary mission involved close encounters with Jupiter—in March and July—by Voyagers 1 and 2, which returned the first high-resolution pictures of the superplanet and five of its moons. Built by NASA's Jet Propulsion Laboratory, the Voyagers provided a wealth of new scientific information, including discovery of a 14th moon orbiting Jupiter, a previously unknown Jovian ring, and the fact that Jupiter's moon Io is the most volcanically active body in the solar system. Among highlights of other planetary investigations,

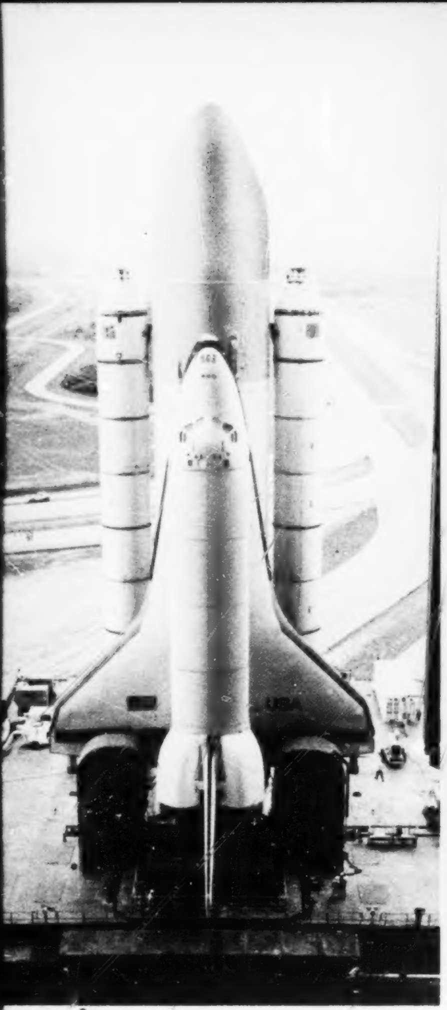
- In September, Pioneer II, built by TRW Inc., flew by Saturn and returned the first close-up pictures of the ringed planet; the spacecraft found that Saturn consists largely of liquid metallic hydrogen, has a hitherto unknown 11th moon and two previously undetected rings.
- In orbit around Venus, the Pioneer Venus spacecraft—built by Hughes Aircraft Company—relayed important new information about the planet, including reports that Venus has mountains higher than Earth's, great plateaus, deep rifts and circular features that appear to be impact craters created early in the planet's history.
- Three years after their initial landings on Mars, the Viking Landers 1 and 2—built by Martin Marietta Aerospace—continued to send photos and data back to Earth. Lander 2, along with one still-functioning Viking Orbiter, will soon cease operations, but Lander 1 is expected to return data for another 10 years.
- In July, the TRW-built Pioneer 10, which departed Earth eight years ago, passed the orbit of Uranus, two billion miles from Earth, on its way to becoming the first man-made vehicle to escape the solar system and course indefinitely through interstellar space.

In other activity, NASA conducted nine launches in 1979, six of them "reimbursables" whose launch costs are defrayed by payload sponsors. The six non-NASA launches included USAF and United Kingdom scientific satellites, a National Oceanic and Atmospheric Administration environmental satellite, a Navy comsat and two commercial communications satellites, one each for Western Union and RCA; the latter was lost after orbital insertion.

NASA's three 1979-orbited spacecraft were:

- SAGE, launched February 17 to gather data on ozone and aerosols in the stratosphere.
- HEAO-3 (September 20), third of the High Energy Astronomy Observatories which are mapping celestial x-ray sources. Principal contractor is TRW Inc.
- Magsat (October 30), which is measuring the near-Earth magnetic field and sending data on magnetic anomalies within Earth's crust, information of value to mineral prospecting in remote areas.

Heading the list of major NASA systems in development status during 1979 was the Space Shuttle, for which Rockwell International is principal contractor. NASA successfully conducted full-duration (550 seconds) testing of the three-engine main pro-



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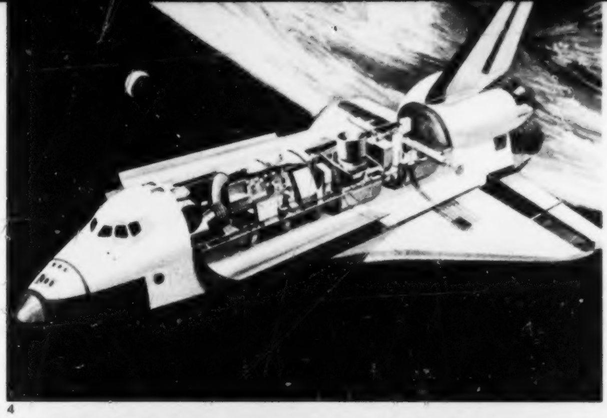

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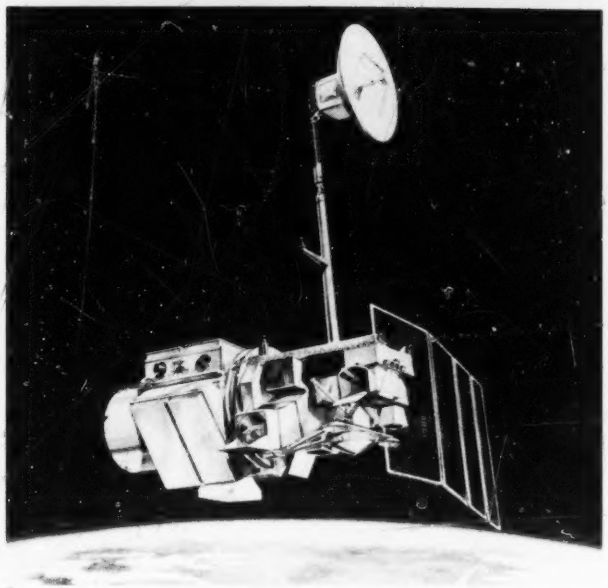

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1. **Highlighting NASA's "Year of the Planets," two Voyager spacecraft flew by Jupiter and returned the first high-resolution photos of Jupiter and five of its moons. The artist's concept depicts Voyager 1's encounter with Saturn, due this fall.**
2. **Launched last February, the SAGE spacecraft is gathering data on ozone and aerosols in the stratosphere.**
3. **Developmental tests of the various components of the Space Shuttle progressed in 1979. First orbital flight was targeted for mid-1980.**
4. **Assembly of the first Spacelab was well advanced at year-end. Initial flight of the multipurpose laboratory aboard the Space Shuttle was scheduled for 1982.**
5. **In development and planned for launch late in 1981 is NASA's Landsat-D, fourth and most advanced member of the family of Earth resources monitoring satellites.**

pulsion system, one of the pacing items in preparing the Shuttle for orbital flight. The major elements of the first flight system—the Orbiter *Columbia*, the external fuel tank and the two solid rocket boosters—were delivered to Kennedy Space Center during the year. First orbital flight was targeted for mid-1980.

Spacelab, a multipurpose human-habitable laboratory which fits into the Shuttle Orbiter's cargo bay, continued in development under the aegis of the European Space Agency. In Bremen, Germany, assembly of the first Spacelab flight unit was well advanced at year-end. The first flight of Spacelab aboard the Space Shuttle was scheduled for 1982.

Other major NASA development programs under way in 1979 included:

- Galileo, a project involving two separate spacecraft—a planetary orbiter and a probe designed to descend through the atmosphere—to be launched in 1984 for an extensive follow-on survey of Jupiter.

- Space Telescope, an advanced astronomical observatory that will permit observations far deeper into space than have ever before been possible.

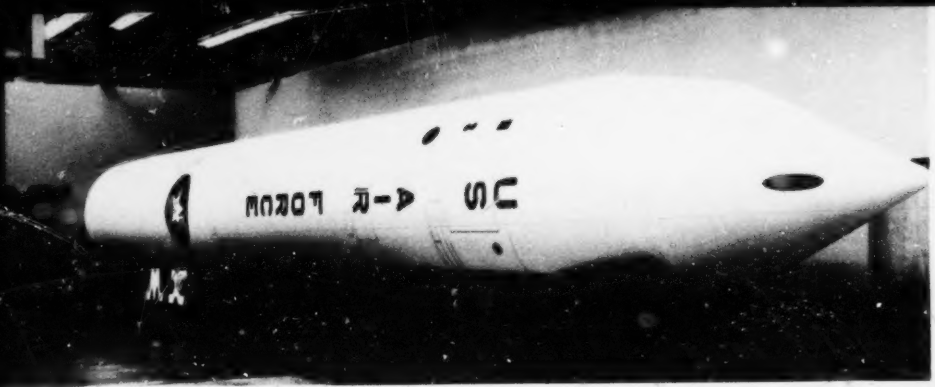
- The Solar Polar Mission, a joint NASA/European Space Agency project to investigate the still unexplored third dimension of solar space out of the ecliptic—meaning around the Sun's poles rather than around its equator. A two-spacecraft team was scheduled for 1983 launch.

- Landsat-D, the fourth and most advanced member of the Earth resources monitoring satellites, to be Shuttle-launched late in 1981. General Electric Company's Space Division is prime contractor.

In military space operations, the Department of Defense launched the second spacecraft in the Navy/TRW Fleet Satellite Communications System, which will provide ship-to-shore, ship-to-ship and ship-to-aircraft links. The third satellite was scheduled for early 1980 launch. Dod also launched two additional spacecraft—the 13th and 14th—of the Defense Satellite Communications System II (DSCS-II); the satellites are built by TRW Inc. Under development by General Electric is the third generation DSCS III, scheduled for first launch in mid-year 1980.

Other than the Space Shuttle, DoD's principal space development activity in 1979 focused on continuing development of the Navstar Global Positioning System, a network of satellites and ground equipment designed to provide precise positioning and other information for more effective operation of ships, aircraft, artillery and armored forces. Testing of an interim eight-satellite system continued with the 1979 launch of the fourth spacecraft; the fifth launch was planned for early 1980. Being developed by Rockwell International and McDonnell Douglas Corporation under USAF cognizance, the Navstar system was scheduled for fully-operational service in the mid-1980s.

Late in 1979, the Air Force announced plans to establish a Consolidated Space Operations Center in Colorado Springs, Colorado. The Center will combine satellite control functions and direction of future DoD Space Shuttle operations.



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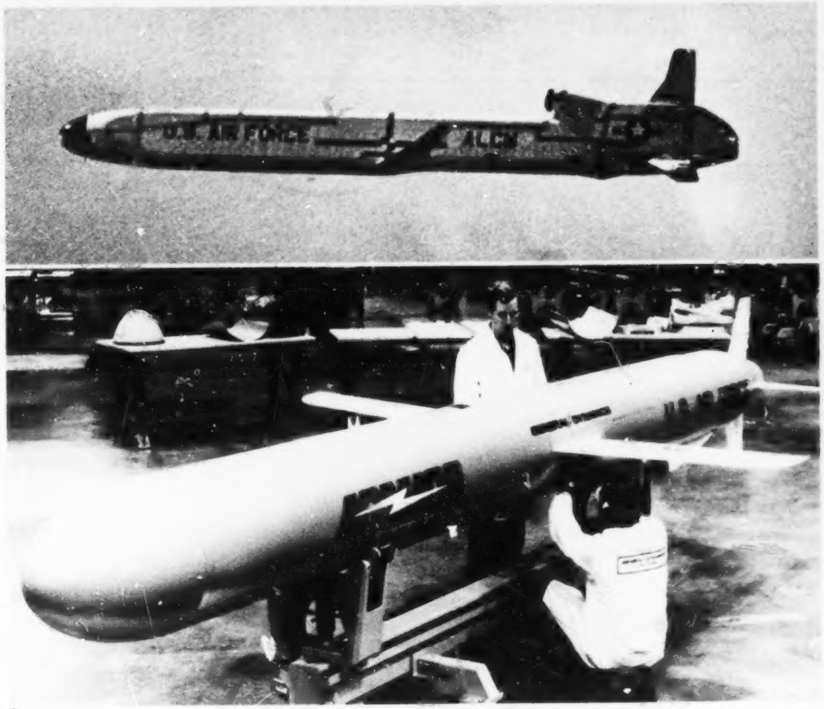

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Defense

A major 1979 defense development was the September announcement of Presidential approval for full-scale development and deployment of the USAF advanced intercontinental ballistic missile system known as MX. The operational system will consist of 200 missiles, each constantly on the move among 20-25 launching shelters built around a "racetrack" complex so that enemy intelligence would be unable to tell which shelter houses the weapon. Thus, the MX system offers greater survivability in an era when the increased accuracy of long-range missiles makes fixed-position ICBMs more vulnerable to attack.

Expected to be fully operational in 1988-89, the system will involve developmental effort on the part of many major aerospace contractors. Among those initially assigned roles in the development program, each handling a particular segment, are Aerojet-General Corporation, The Boeing Company, Hercules Incorporated, Honeywell Inc., Martin Marietta Aerospace, Northrop Corporation, Rockwell International Corporation, Thiokol Corporation, TRW Inc., United Technologies Corporation and Westinghouse Electric Corporation.

Hercules Incorporated, Honeywell Inc., Martin Marietta Aerospace, Northrop Corporation, Rockwell International Corporation, Thiokol Corporation, TRW Inc., United Technologies Corporation and Westinghouse Electric Corporation.

The Navy's Trident 1 fleet ballistic missile, built by Lockheed Missiles and Space Company, achieved initial operational status late in 1979 when the Trident-armed submarine *USS Francis Scott Key* completed its first patrol. A second Trident sub was scheduled for patrol duty early in 1980.

DoD cruise missile development advanced with further flight testing of the Boeing AGM-86B Air Launched Cruise Missile and the General Dynamics AGM-109, air-launched version of the Tomahawk. By year-end, each of the missiles had completed seven of a planned 10 flights. The ALCM fly-off competition is to be completed early in 1980 and a production decision is expected in the spring. Also under test during the year were the ground-launched and sea-launched versions of the Tomahawk; in November, a sub-launched Tomahawk flew a fully-guided successful flight. Production of the ground-launched Tomahawk was planned in 1980.

In other missile developments:

- In December, member nations of the NATO alliance approved a modernization program calling for deployment in 1983 of 10[illegible]my/Martin Marietta Pershing 2 [illegible]um-range ballistic missiles and [illegible] ground-launched cruise missile[illegible]
- The Army awarded initial contracts

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1. Shown in full-scale mockup is the USAF's new mobile MX intercontinental ballistic missile, targeted for initial flight in 1983 and fully operational status in 1989. Plans call for deployment of 200 missiles, each carrying 10 warheads.
2. In flight test status during 1979 were the Boeing AGM-86B (above) and the General Dynamics AGM-109 air-launched cruise missiles.
3. The Navy McDonnell Douglas F-18A Hornet completed a series of sea trials aboard the aircraft carrier USS America in November.
4. In pre-production status was the Air Force/Lockheed-California TR-1 reconnaissance aircraft, a variant of the U-2R in service with the Strategic Air Command.
5. First flight of the Army/Hughes YAH-64 helicopter with its new, movable tail was accomplished in October. Time flown by two prototypes of the Advanced Attack Helicopter topped 1,000 hours.
6. The first prototype of the Navy/Sikorsky SH-60B Seahawk helicopter made its initial flight in December.

for U.S. production of the French/German air defense missile to Boeing Aerospace Company and Hughes Aircraft Company.

- The Army/Rockwell International Hellfire antiarmor missile passed a developmental milestone with first "autonomous" launches—using a helicopter-borne target-marking system—from the Hughes-built YAH-64 Advanced Attack Helicopter.

- Development continued on the Army/General Dynamics Viper short-range shoulder-fired antitank weapon, scheduled for initial operational capability in 1981.

In DoD aircraft development, the Navy/McDonnell Douglas F-18A Hornet successfully completed a series of sea trials aboard the aircraft carrier *USS America* in November. Development continued on the companion land-based version of the Hornet, the Northrop F-18L. The F-18A is in large-scale production.

Among other military aircraft developments:

- The Air Force awarded Lockheed-California Company an initial production contract for the TR-1 reconnaissance aircraft, the start of a program intended to provide 25 TR-1s for the USAF and one ER-1 Earth-survey version for NASA.
- DoD's two high-performance air superiority fighters, the Navy/Grumman F-14 Tomcat and the USAF/McDonnell Douglas F-15 Eagle, continued in production.
- General Dynamics continued deliveries to the USAF of the F-16 fighter and at year-end was preparing for first deliveries to Norway and Denmark, expected early in 1980.
- The first USAF/McDonnell Douglas KC-10 advanced cargo/tanker aircraft was in final assembly at year-end, with delivery planned for October 1980; the company received orders for four additional KC-10s, making a total of six ordered in a program expected to number 20 planes.
- In October, the McDonnell Douglas YAV-8B Advanced Harrier VTOL fighter continued its developmental progress with completion of sea trials aboard the *USS Saipan*, a helicopter amphibious assault vessel.
- December marked the first flight of the Navy/Sikorsky SH-60B Seahawk helicopter, being developed as a Light Airborne Multipurpose Systems (LAMPS) vehicle. Sikorsky continued deliveries to the Army of the companion UH-60A Black Hawk tactical/utility transport. The company received a new Army contract for development of another Black Hawk derivative, the EH-60B Stand-Off Target Acquisition System (SOTAS).
- The Army/Hughes YAH-64 Advanced Attack Helicopter achieved a major test milestone in October with the first flight of a prototype equipped with an advanced-design movable tail.

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1. In October, McDonnell Douglas started flight tests of the DC-9 Super 80, which was targeted for mid-year 1980 certification.
2. Newest member of the Lockheed L-1011 TriStar family is the long-range Dash 500, first production model of which flew in November.
3. Boeing's Vertol's Commercial Chinook is scheduled for first flight in mid-1980 and service entry in mid-1981.
4. Sikorsky delivered 37 units of the S-76 Spirit during 1979.
5. In 1979, the Federal Aviation Administration began commissioning a new generation of advanced-design long-range radars. FAA plans to install 27 of the Westinghouse-built ARSR-3 Air Route Surveillance Radars.

Civil Aviation

The nation's scheduled airlines set new traffic records in 1979, boarding some 300 million passengers and accounting for more than 80 percent of all public intercity passenger miles. Passenger traffic rose about 12 percent above the previous record year 1978.

However, the airline industry's earnings fell off sharply, due to rising costs, in particular the soaring cost of fuel. Earnings in 1979 declined to less than half the record $1.2 billion level of 1978 — despite the fact that overall revenues increased $5 billion to $27 billion. The Air Transport Association viewed the earnings drop as "disturbing," in view of capital formation needs for acquisition of quieter, more fuel efficient advanced technology transports. The new plane funding requirement for the decade of the 1980s was estimated at $90 billion.

At year-end, the U.S. scheduled airline fleet numbered about 2,400 aircraft. Airline industry employment continued to grow through the first three quarters of 1979, then dipped in the fourth quarter, ending up above 300,000. Average annual compensation was more than $30,000, one of the highest of all U.S. industries.

In the commercial transport segment of the aerospace industry, manufacturers continued development of the advanced technology family of jetliners scheduled to begin service in the early 1980s. In October, McDonnell Douglas initiated flight testing of the DC-9-Super 80 twinjet transport, which was targeted for mid-year 1980 Federal Aviation Administration certification. The first production model of Lockheed's new L-1011-500 long-range TriStar flew in November. In early fabrication status are Boeing's three-engine 767 transport and its twinjet companion, the 757; first deliveries of the 767 are scheduled for mid-1982 and initial 757 deliveries are planned for early 1983. U.S. commercial transport manufacturers received large-scale orders for both new and existing types of jetliners during the year and the transport backlog climbed by more than $6 billion to a record $22.2 billion.

Sales of civil helicopters reached an all-time high in 1979 and the surging growth of that segment of the aerospace industry's workload was expected to continue through the 1980s. Among the rotary wing highlights of 1979:

- Sikorsky Aircraft began deliveries of its twin-turbine S-76 Spirit and by year-end had delivered 37 of the civil transport helicopters; total orders amounted to almost 300 aircraft.
- Certification flight testing of Bell Helicopter Textron's Model 222 twin-turbine transport neared completion and first deliveries are scheduled for early 1980; orders topped 150 units.
- Development work continued on the Boeing Vertol Commercial Chinook, a tandem-rotor high-payload transport helicopter scheduled for first flight in mid-1980 and service entry in mid-1981.

In rotorcraft research, flight testing continued on three major programs, jointly sponsored by NASA and the military services, which offer both civil and military potential. Bell Helicopter Textron's XV-15 Tilt Rotor Research Aircraft successfully completed an initial series of in-flight conversion tests, in which the craft's rotors tilt forward after vertical takeoff to become propellers for cruise flight. Sikorsky completed company testing

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of two Rotor Systems Research Aircraft and the craft were turned over to NASA for advanced flight testing of rotor and propulsion systems. Sikorsky's ABC (Advancing Blade Concept) helicopter continued in the high-speed phase of its flight test program, reaching speeds of 200 knots en route to the goal of 300 knots.

In other NASA flight research, the AD-1 Oblique Wing Research Aircraft (whose wing can be pivoted in flight for maximum aerodynamic efficiency) made its first test flight in December. Flight testing continued on the Boeing-built Quiet Short-Haul Research Aircraft, designed to develop technology for future, extremely quiet airliners and to demonstrate the propulsive lift concept which will enable tomorrow's short-haul transports to operate from very short runways. Following initial contractor testing, Avco Corporation's Lycoming Division and Garrett AiResearch Manufacturing Company each delivered to NASA its version of the Quiet, Clean General Aviation Turbofan experimental engine, designed for significant reductions in noise and emissions.

Among Federal Aviation Administration activities in upgrading the national air traffic control/air navigation system, a highlight was the June commissioning of the first of a new generation of long-range radars at Arlington, Iowa. Built by Westinghouse Electric Company and known as the ARSR-3 (Air Route Surveillance Radar), the equipment incorporates many advanced design features that enhance both its operational capabilities and its reliability. FAA has ordered a total of 27 ARSR-3s, including four mobile units, and is commissioning them at a rate of approximately one a month.

In addition, the agency began installing a new computerized radar back-up system in its enroute control centers. When operational, the new Direct Radar Access Channel (DARC) equipment will give center controllers the same basic data on their scopes—such as aircraft identity and altitude—as the present primary system. It will eliminate the need for controllers to revert to the old "broadband radar" system, which shows only aircraft targets, when the primary system fails or is shut down for maintenance. The first of the new installations is scheduled for commissioning at the Salt Lake City center in February 1980, with installations at all 20 domestic centers on line by mid-1981.

Another major development was the award of a $78.5 million FAA contract to begin replacing all vacuum-tube radio navigation aids with new solid-state equipment. The contract calls for production and installation of 586 navigation aids (VORs and VORTACs) with an option for an additional 364 more.

Airport planning and development programs reached record levels in 1979 with a total of over $650 million expended. FAA is giving increased emphasis to the development of satellite fields in major metropolitan areas in order to relieve congestion at busy air carrier airports. Approximately $100 million will be set aside for this purpose over a four-year period, with some 86 airports in 56 metropolitan areas targeted for improvements. Development projects will include runway, taxiway and apron improvements as well as installation of instrument landing systems, visual landing aids and automated weather reporting equipment.

The editors of Aerospace magazine recently became aware of an exceptional new book on the Wright Brothers. In the following review, Associate Editor James J. Haggerty, himself one of the nation's foremost aviation writers, gives his view on *Kill Devil Hill*, written by Harry Combs, president of Gates Learjet Corporation.

One is inclined to ask, on picking up *Kill Devil Hill*, why another book on what the Wrights wrought at Kitty Hawk? What more is there to say? What stone had prior historians left unturned?

The answer is that *Kill Devil Hill* is not just another book on the Wrights but an exhaustively researched aviation classic. Harry Combs—and several associates he credits with research/editorial help—found hundreds of stones to turn over. A wealth of hitherto unpublished or obscure facts and a mass of exquisitely detailed background information are skillfully woven into a fresh and exciting account of the first decade of powered flight. Brilliantly written, the book has the pace of a novel and on occasion a trace of lyricism. Suspense, of course, is patently impossible to achieve in so often told a story—yet the reader finds himself wondering at times if the Wrights would really succeed. Combs extensive research pays off in his strong characterization of the Wrights, who come alive in this work where in many others they seem monodimensional.

Perhaps *Kill Devil Hill's* greatest contribution to historical perspective is Harry Combs treatment of *exactly* what the Wrights accomplished. They were not, he takes pains to point out, a couple of experimenters who came along at the right time to take advantage of the research already performed by their 19th century predecessors. Quite the contrary. The Wrights found that the existing theories of flight were wrong. They were forced to develop from scratch, then prove, their own theories of lift, control and propulsion—and that was the real miracle of Kitty Hawk. Combs covers in great detail the enormous problems the brothers faced and the solutions they found. His own vast knowledge, based on half a century of flying experience, enables him to reduce complicated technical considerations to language readily understandable to the layman—and thus the reader gets a new appreciation of the magnitude of the Wrights monumental achievement.

Harry Combs is president of Gates Learjet Corporation, which brings up the question of why the busy head of a major industrial firm would take the time to write so comprehensive a volume. In a prologue to *Kill Devil Hill*, Combs explains. The explanation is a story in itself, and in telling the *why* Combs also provides a key to the content of his book. An excerpted portion of Combs prologue follows.

Think of a time when man could *not* fly. It seems so long, long ago, smoldering in its own ashes of antiquity.

Not to fly is to be chained to the ground, and not merely in the physical sense: it is to be outraged by this heaviness of both body and spirit, to feel that our world was bigger than the entire solar system, that our vision was limited, our grasp feeble, our tomorrow creakingly ancient and wheezing no matter what our accomplishments.

Not to know flight, not to soar and glide and to grace the heavens with our wings and embrace within them an entire planet, is to be *caged*. And that is not for men.

This sleek jet with which I cruise the upper atmosphere emerged from the Earth, fashioned by the *hands* of men—hands *and brains*. And from all this came metals and alloys and ceramics and wires and glass and plastics and electronics and fabric and the squeezed and flame-lashed remnants of fossil fuels that drive this magic carpet.

I fly at 550 miles an hour nine miles above the earth.

What in the hell holds us up?

What makes this mass of metal *fly*?

How did we capture this miracle? Who gave it to us? Where did it all start?

I think back to the day not long ago when I experienced an awful shock—the realization that I had spent 50 years flying through the skies above the Earth without really knowing the true story of how flying all began.

This was a staggering blow, but I discovered that I was not alone and that my lack of knowledge was shared by most people, even those who fly. We have taken flight for granted. And I, like so many others, had pictured the Wright brothers as a couple of boys who ran a bicycle shop in Dayton, Ohio, and who kept fiddling around with the idea of a flying machine until finally they staggered into the air. Nothing could be further from the truth.

My awakening was brought about by the kindness and interest of a great friend who one day walked into my office with two books under his arm.

He is a man of sensitivity and depth. He knew of my concern, and having considerable knowledge of the Wrights' accomplishments, he had obtained copies of *The Papers of Wilbur and Orville Wright*, which were originally published in 1953[1] under the editorial direction of Marvin W. McFarland of the Library of Congress, and these were the volumes he now presented to me. He said that he was giving me the books to aid me in the future when I discussed the Wright brothers. The fact that he had been an accomplished test pilot and a professor of aeronautical engineering, as well as the first man to set foot on another celestial body in this galaxy,[2] did not detract from the authority of his opinion.

He might as well have placed a time bomb on my desk. I began to read—first, with mild interest; and then, for a time, I knew no other world. Between the lines there arose an image of high drama, and a bitter struggle to overcome almost impossible odds.

I learned, to my surprise, that when the Wrights finally succeeded in flight, their accomplishment was shrouded, through an incredible series of circumstances, in almost total obscurity. This may account for the phenomenal American ignorance of the Wrights. Real news of their achievement did not burst upon the world for five long years.

Few Americans know the story of that recognition, which included processionals of presidents and kings, princes and prime ministers, financiers and scientists, jeweled and beautiful women—all a seemingly endless and tumultuous acclaim for the wonder that had been wrought.

I was determined to tell this story, and in order to tell it properly I would travel all over America and Europe and back—visiting the shrines of flight, from Kitty Hawk and Simms Station to Le Mans and Pau, from Stanford Hall to Hawthorn Hill, from Fort Myer, Virginia, to Camp d'Auvours, France—searching for and dreaming in my mind's eye about what had really happened there. I wanted to walk in the footsteps of those incredible brothers, to picture their historic flights, and to hear the popping clatter of those rickety old homemade, four-cylinder engines

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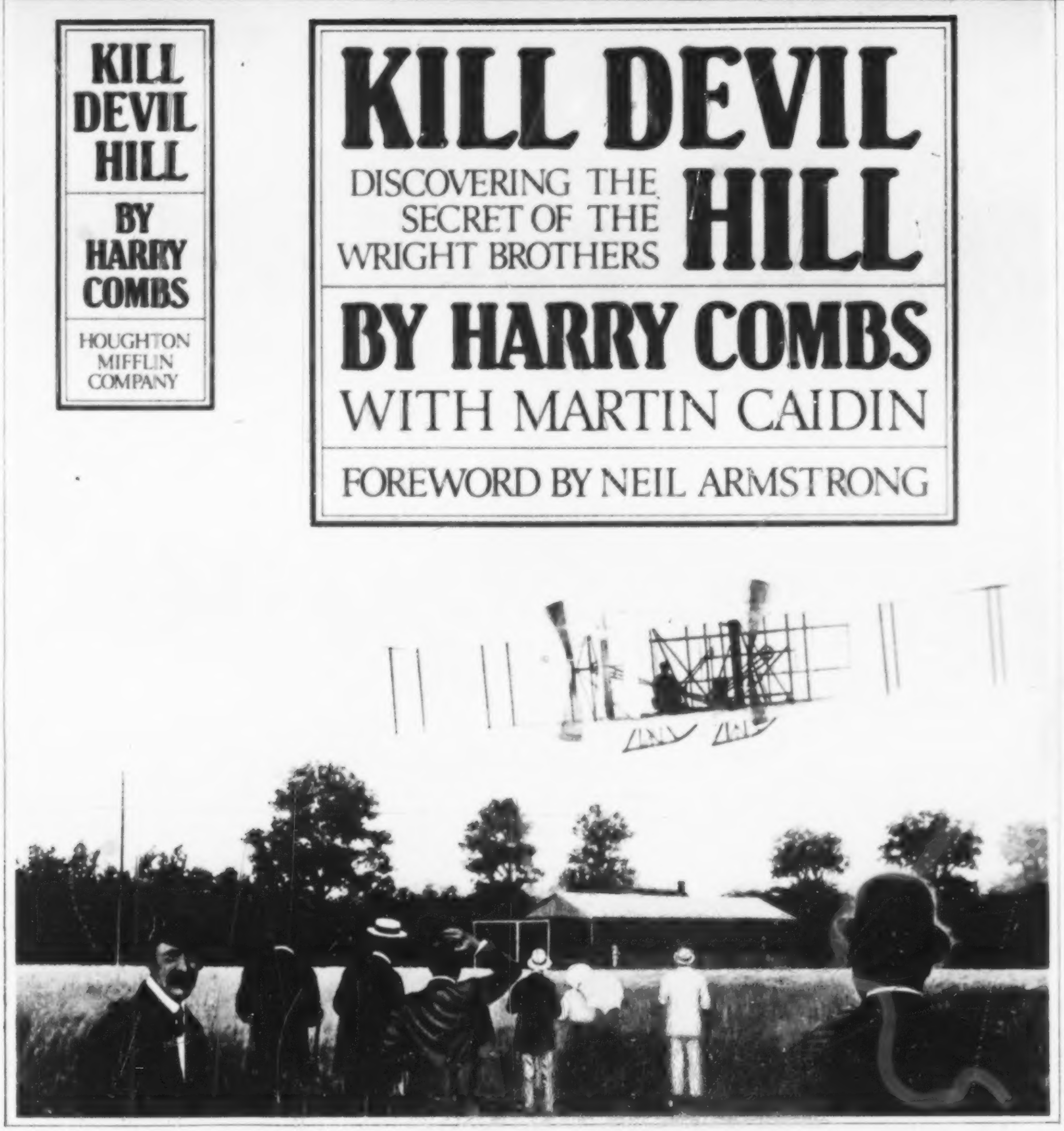
[1] McGraw-Hill Book Company, Inc

[2] First moonwalker Neil Armstrong



KILL
DEVIL
HILL
BY
HARRY
COMBS
HOUGHTON
MIFFLIN
COMPANY

KILL DEVIL HILL
DISCOVERING THE
SECRET OF THE
WRIGHT BROTHERS
BY HARRY COMBS
WITH MARTIN CAIDIN
FOREWORD BY NEIL ARMSTRONG

Harry Combs

and the whir of fragile, fledgling wings.

And before it was done, I would visit many museums and study all kinds of ancient flying contraptions. I would race against time to talk with men and women still living who had known the Wrights personally—before their recollections were lost forever.

Interestingly, in recent years a number of highly trained and experienced airplane designers and builders have attempted to construct and fly "authentic" replicas of the original *Kitty Hawk Flyer*. None of the reproductions ever flew successfully. Missing were the precise conditions at Kill Devil Hill that chilly December day in 1903, but so was the most essential factor of all: the unique genius of the Wright brothers themselves.

It is my purpose to share my delight in discovering the fascinating drama of a decade when the energy and the intellect of two remarkable brothers burned their brightest. Perhaps parts of this story will illuminate some aspects of what these men did and how they did it. To my knowledge, many of the physical reasons for the success of some of their flights, and the failure of others, have never before been fully explained or even explored.

Some questions have remained unanswered for more than three quarters of a century:

How did the Wrights achieve in just four and a half short years what the best minds of the world had failed to accomplish in centuries?

What was the real significance of that quantum jump in developing their own body of empirical data—a jewel beyond price, without which flight was impossible?

What was the happy accident of design that enabled them to learn to fly without killing themselves?

Why did they court the press at first, then retreat into a secrecy that masked their work in later years?

Why did they abandon flying for two and a half crucial years, from November 1905 until May 1908?

And why were the great flights of the brothers in France and at Fort Myer, Virginia, far more important than their first flights at Kitty Hawk?

And now, flying along the edges of space, I marvel at the achievement of these two great minds . . . at the strength of their courage and determination that appears in every page of their letters and diaries . . . and I am ashamed of my own ignorance, and, being an American and a flier, I realize that I had almost missed my own heritage—almost, but not quite.

This is a pilgrimage, a search for the truth about that great adventure. There remains much to tell about the brothers, and there is more to be discovered, but right now this pilgrimage itself seems like high flight: beautiful, exciting, and, in the terms of the airman, "way out in the wild blue yonder."

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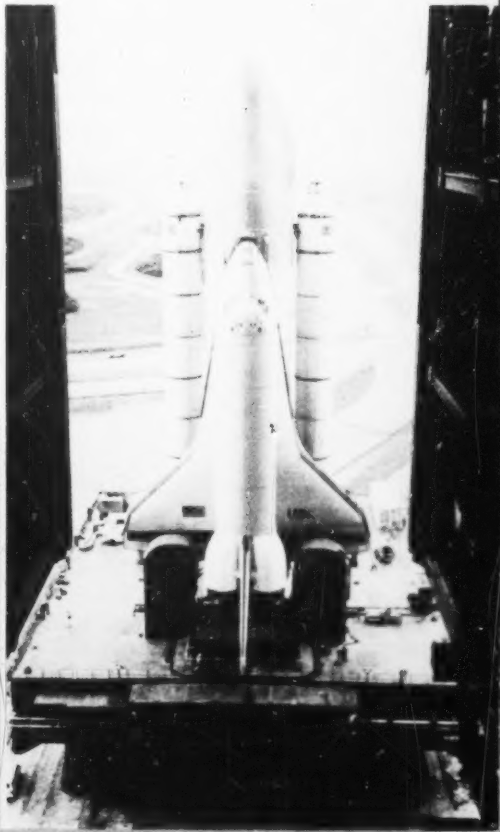

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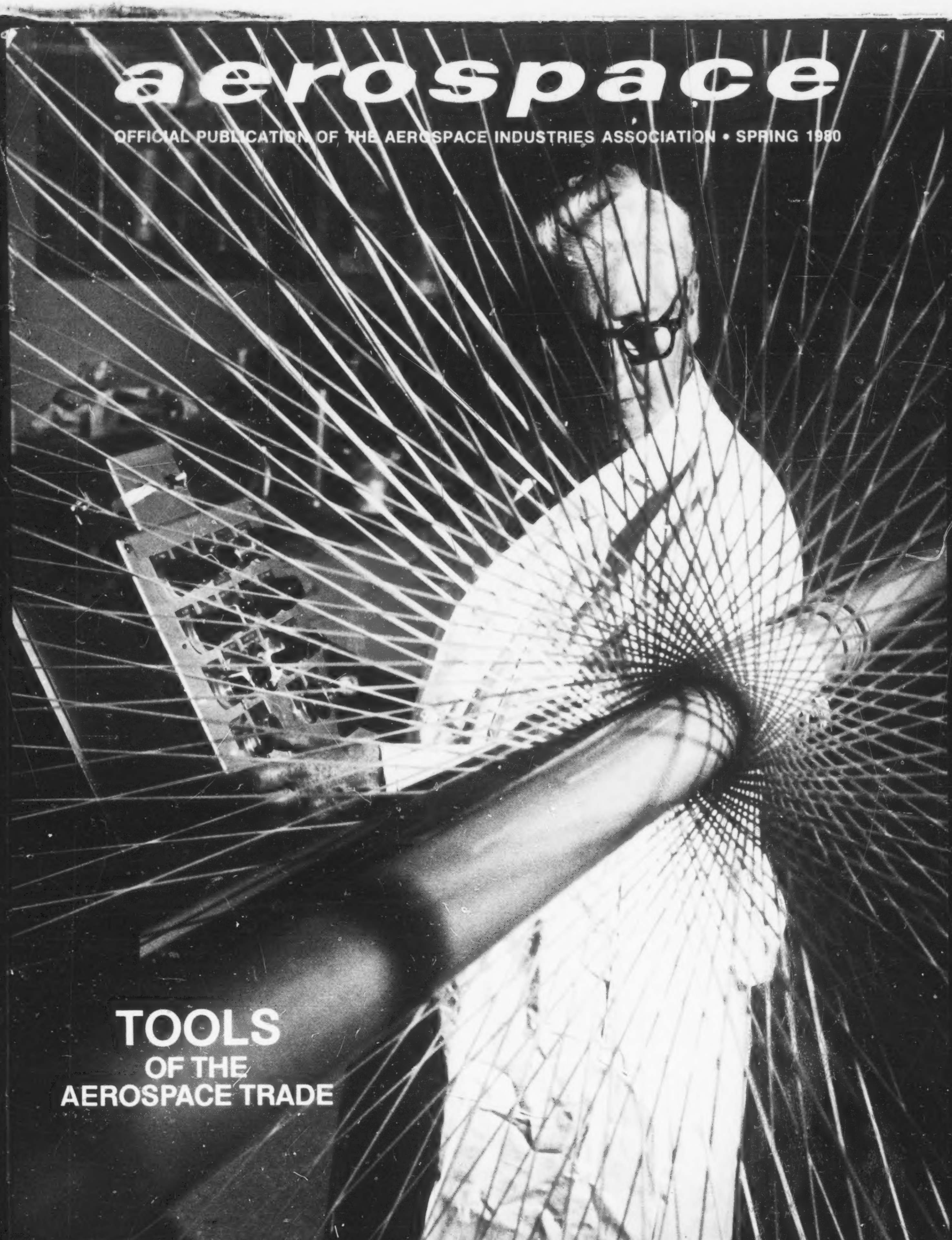

TOOLS
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Notable views of notable people on aerospace matters...

aerospace perspectives

In this Presidential election year, the views of the candidates are of interest to all Americans. Recently, the leading contenders expressed their positions on many issues in a book published by the American Enterprise Institute. The book is part of on-going research partially funded by a grant from the LTV Corporation. "The Candidates 1980—Where They Stand," covers numerous issues. Aerospace magazine, because of its readers' special interest in defense affairs, received permission from AEI to present excerpts of statements made by leading candidates about one issue: "What would be the elements of your defense policy? How would you ensure the success of your vision of America's future in a changing world?"

Representative John B. Anderson:
"First, we need a strong, innovative research and development community within and outside the government. Second, we need an intelligence community better able to identify threats and opportunities. Third, we need improved cooperation among our allies on defense, energy, economic and other political areas of common interest. Fourth, we need to better insulate our economy from foreign interference with our energy and raw material supplies.

"Finally, we need to demonstrate both our willingness to cooperate with other nations in such diverse fields as arms control, science and technology, and cultural affairs and our willingness to compete in military forces, political propaganda and economic matters. By demonstrating both our competitive and cooperative spirit through deed as well as word, I believe our nation will encourage international cooperation and be more secure in the long term."

George Bush:
"Two critical questions now confront us in national defense. First, how can we best restore our military strength? Second, who is best qualified to serve as our commander-in-chief during perilous times?

"Fortunately, the country has finally woken up to the fact that we are entering a decade of great danger. For the first time in our history, our strategic forces will be seriously vulnerable to Soviet attack and our conventional forces will be inferior. Events in Afghanistan should also leave no doubt that the Russians will take advantage of weakness wherever they find it.

"It is thus obvious that we must press forward with a sustained build-up of our forces. Among our highest priorities should be the development and deployment of a new manned bomber, a long-range cruise missile, a greatly strengthened three-ocean Navy, and expanded airborne and seaborne tactical forces . . .

"These changes will cost money—more than is called for in the Administration's new budget. But we can no longer afford policies built more on bluff than true brawn."

President Jimmy Carter:
"The President's defense program emphasizes these areas: 1) ensuring that our strategic nuclear forces will be equivalent to those of the Soviet Union and capable of deterring any nuclear aggression; 2) upgrading our forces so that the military balance between NATO and the Warsaw Pact will continue to deter the outbreak of war; 3) providing forces to give us the ability to come quickly to the aid of friends and allies around the globe; and 4) ensuring that our Navy continues to be the world's most powerful. This program includes cruise missile production to modernize our strategic air deterrent, B-52 modernization, and upgrading the strategic submarine missile force.

"The new MX missile will enhance the survivability of our land-based intercontinental ballistic missile force. In addition, the program calls for accelerating our ability to reinforce Western Europe with massive ground and air forces."

Senator Edward M. Kennedy:
"A military lesson of the post-World War II era is that nuclear and gold-plated conventional weapons have tended to make us missile-bound and less combat ready. That is why, as we look ahead at the decade before us, our emphasis should be not only on strategic deterrence but on developing and strengthening a general purpose force that is fighting-trim, equipped with workable and working weapons, and relevant and ready for the conduct of various regional missions . . .

"The United States must modernize and expand its military force in concert with its Atlantic and Pacific allies . . . One certain way *not* to improve America's capability is to engage in an empty debate over arbitrary percentages of budget growth. Anyone who is serious about national defense knows what the nation needs is not a three percent, five percent or seven percent solution in defense spending. What we need are defense resources effectively directed to actual military requirements and assurances that our nation can rely upon capable and cost-effective military weapons. I have in mind such weapons as the air-launched cruise missile, which provides us with a military advantage at far less than what it costs the Soviet Union to counter it. I have in mind that these weapons be manned by skilled and experienced personnel. And I have in mind that our armed forces be headed by committed and confident leadership."

Ronald Reagan:
"My first priority would be to embark on a program of rebuilding American military strength. Selectively and prudently, we must commit our resources to achieving this goal.

"We have permitted ourselves the luxury of believing that our principal adversary, the Soviet Union, shares our hopes for peace and our trust in mutual restraint through good example. That this leads to policies endangering our national security is now abundantly clear.

"At a minimum, we must move quickly to restore the principal elements of the last Republican defense budget and just as swiftly establish strategic goals.

"Finding the resources to do this job will definitely not be easy, but I believe we can take an initial step by redirecting the misspent resources presently being consumed by a huge government bureaucracy . . . Specifically, restoring the credibility of our deterrent power must come before anything can be accomplished."

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COVER

At McDonnell Douglas Corporation, an automatic braiding machine winds filaments around a core to produce lightweight ducts for aerospace applications. The machine is representative of the sophisticated tools and equipment needed to produce modern aerospace systems (see page 8).

The purpose of AEROSPACE is to:

Foster understanding of the aerospace industry's role in insuring our national security through design, development and production of advanced weapon systems.

Foster understanding of the aerospace industry's responsibilities in the space exploration program.

Foster understanding of civil aviation as a prime factor in domestic and international travel and trade.

Foster understanding of the aerospace industry's capabilities to apply its techniques of systems analysis and management to solve local and national problems in social and economic fields.

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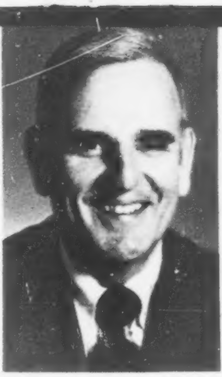
TECHNOLOGY IN THE NEXT DECADE



BY T. A. WILSON
Chairman and Chief Executive Officer
The Boeing Company

This guest editorial, based on an article by Mr. Wilson in *Astronautics and Aeronautics*, is one of a series of commentaries on key national issues by senior aerospace industry officials. Their views, together with the views of AIA president Karl G. Harr, Jr., will appear in alternate issues of *Aerospace*.

Lately, our nation seems overburdened with Cassandras. Self-appointed doomsayers keep telling us that the end is near and that we cannot cope with the complex issues of rising population, energy shortages, dwindling natural resources, and the environmental problems associated with these. They do not recognize the necessity of technological solutions. In fact, they claim that technology is a cause rather than a cure for many of our problems.

Some seem to yearn for the good old days when life was simple and uncluttered with such things as jet transports, television, insecticides, nuclear powerplants, widespread use of electricity, labor-saving devices, modern highway systems and so on. But I notice that most of these back-to-nature lovers never experienced the hard realities of the "good old days." Doing without is a philosophical exercise, not a physical one.

I do not have much sympathy for people who want to stop the world and get off because they are afraid to move ahead. I think they represent a small minority—but a very noisy one.

I am not known as an eternal optimist, but in some respects I would consider this the best of times if I were a young scientist or engineer preparing to begin my professional career. Our problems, as Henry Kaiser once observed, are only opportunities in work clothes.

Consider the state of the aerospace industry. As we enter the decade of the eighties the air transportation business is on solid footing, even though uncertainties in the cost and supply of fuel may constrain its growth. During a large part of the next decade, the airplane manufacturers will be kept busy producing aircraft to meet market requirements. We will continue to make product improvements, and we might see the introduction of giant airliners capable of carrying 600 to 1,000 passengers. Some of my colleagues think a supersonic transport is next, but I am not convinced. I still believe that somewhere down the road there is a market for an economically viable SST, but it will require great advances in aerodynamics, structures and propulsion technology.

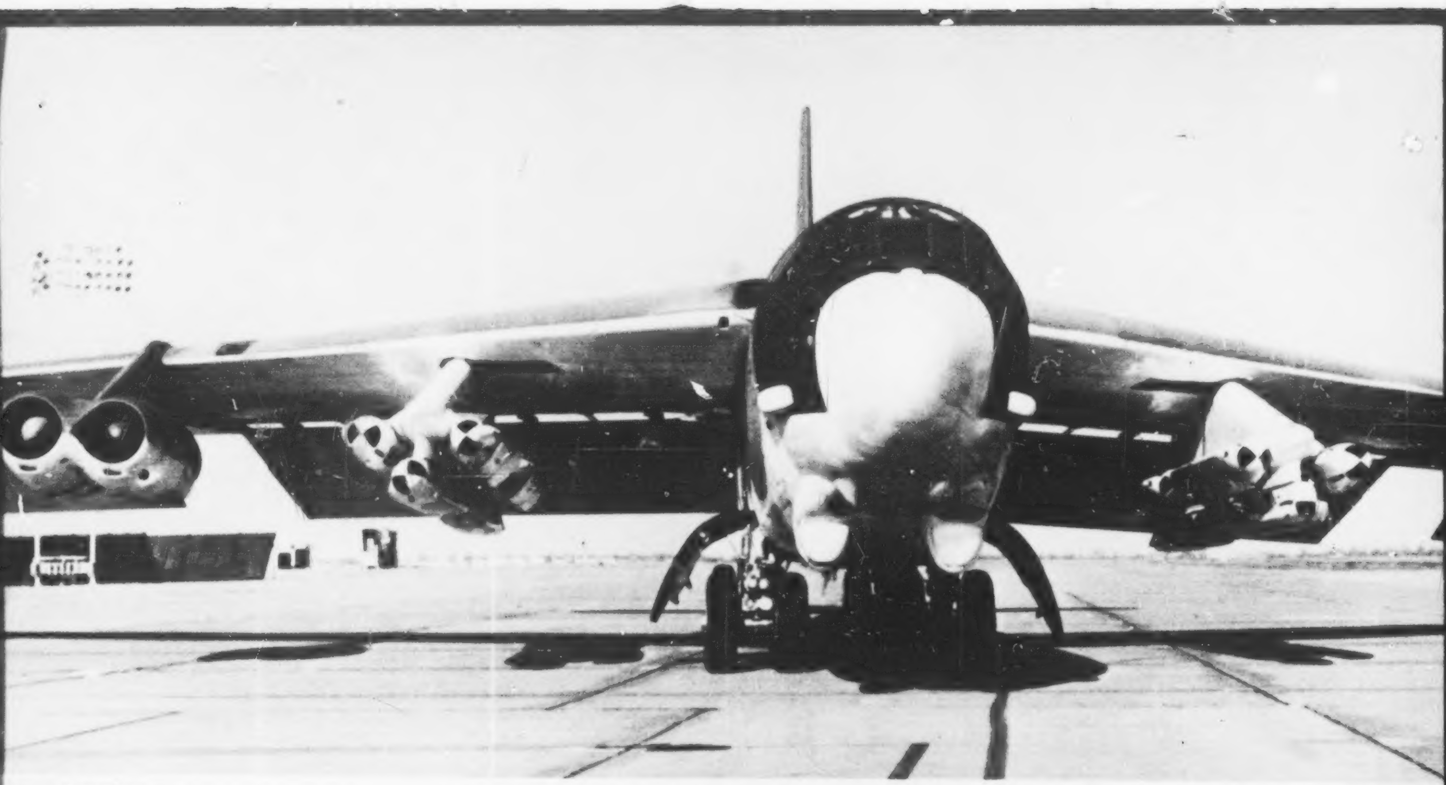
In space, the next decade should see a new level of effort and accomplishment. The Space Shuttle and its supporting systems will give us economical access to orbiting platforms where we can extend our space-based capabilities.

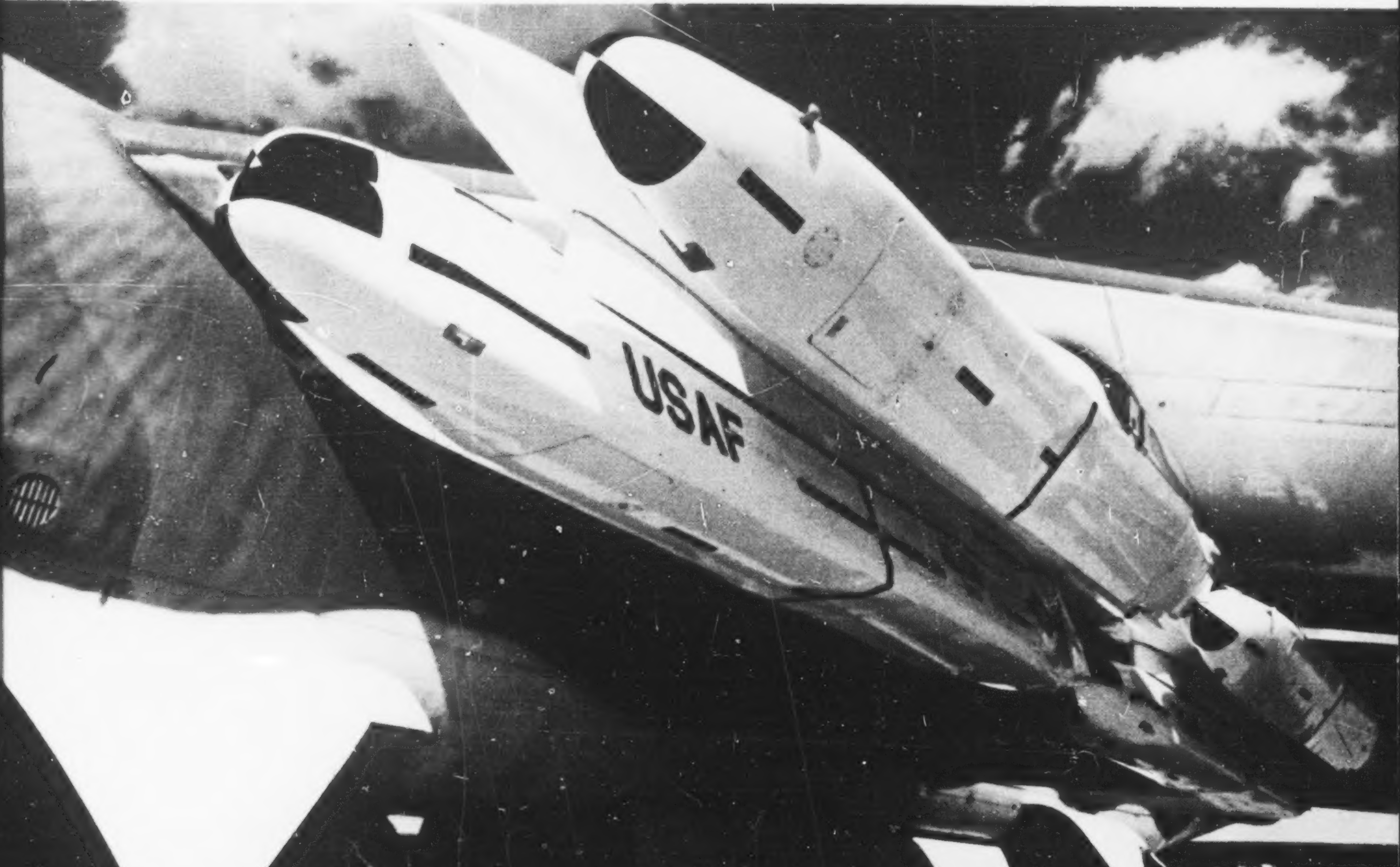
The military situation is such that we must modernize and expand our armed forces. That means high technology weapon systems. In this case, the national mood seems to support a stronger defense posture.

Our biggest current problem is energy. It affects everything else. I think we will make significant progress during the 1980s. That may sound optimistic when you consider how inept our performance has been so far, but our ineptitude is largely a result of political paralysis. Technology can make a big dent in this problem if our industrial workhorse is given full rein. Otherwise, we may be in for cold winters.

The nation's efforts to deal with energy and environmental issues reflect a national mood which makes it difficult to solve any controversial problem. Sometimes the problem is not even well defined. Different pressure groups are suspicious of other groups' motives and various courses of action are proposed, frequently in direct opposition. State and federal legislatures respond with specific laws interpreted and administered by regulators who control a lot of *stop* buttons, but very few that say *go*. The result is a bureaucratic logjam which no amount of executive skill can blast loose.

I think the pattern is shifting. Both Congress and the Administration have recognized that private enterprise is being strangled by overly restrictive legislation and government red tape. I think U.S. industry will be given more breathing room because it alone possesses the ability to develop the products and systems needed to work our way out of the mess we are in.




USAF

By LT. GEN. KELLY H. BURKE, USAF

FUTURE OF THE MANNED BOMBER

▲ The Boeing B-52G is being modified to carry cruise missiles in underwing pylons. Air Force plans contemplate later modifications which will permit the B-52 to carry 20 missiles, eight internally and 12 externally.

◀ Closeup view shows how six cruise missiles are mounted on each of two B-52G underwing pylons.

I would like to share some of our thinking and planning in the Air Force on the subject of the bomber leg—or as it's now being called, the air-breathing leg—of the strategic TRIAD. There is general agreement that we will continue to maintain the air-breathing leg as one of the cornerstones of our strategic deterrent posture. But the future composition and characteristics of that leg are much less clear. Some see the advent of air launched cruise missiles, or ALCMs, as leading to the end of manned penetration, with the air-breathing leg becoming an all stand-off force, perhaps as early as the end of this decade.

The Air Force, however, is convinced that a mixed force including a large number of cruise missiles and a lesser, but still consequential number of manned penetrators, is the most effective and most cost-effective solution.

The case for the Air Launched Cruise Missile is simple and compelling. Large numbers of ALCMs will stress and dilute Soviet defenses, thus improving the overall penetration prospects of the mixed force. Moreover, expansion of the ALCM force offers an excellent near-term opportunity to increase the numbers of weapons in our strategic forces at a relatively low cost and thereby maintain at least some lead in this key index of strategic capability. We are far enough along in the development program to be convinced that the ALCM will work well and will make a major contribution to our deterrent capability at a reasonable cost.

For the near term, our major modernization effort for the air-breathing leg will be the introduction of large numbers of ALCMs, to be carried, at least initially, on modified B-52s. The first of these ALCMs will become operational in less than three years. The pace of conversion is such that some B-52s will remain in the penetrating role throughout the 1980s. Thus, for most of the decade we will have a mixed air-breathing force composed of both ALCMs and penetrating bombers.

The B-52G will be modified to become our first cruise missile carrier and this program is underway; the first squadron will become operational in December 1982. Initially, the B-52 will retain its penetration capability and will be deployed with only external cruise missile carriage, retaining the short range attack missiles and gravity bombs now carried in the bomb bays. In the mid-80s, we will complete the external modification of the 173 B-52Gs and will begin modifying them for internal cruise missile carriage as well. By 1990, the B-52Gs will be completely converted—with each carrying 20 cruise missiles, eight internally and 12 externally—and will become an all stand-off force.

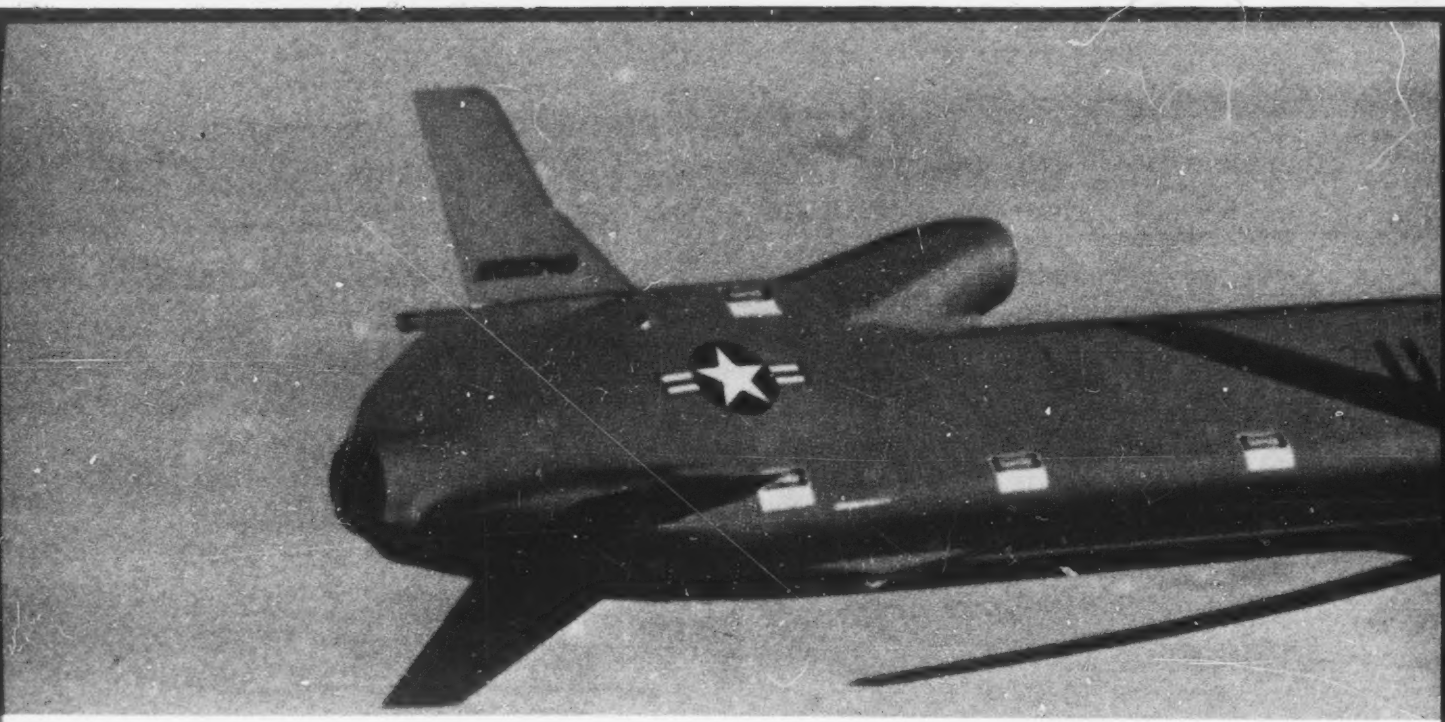
In addition, we plan to complete the development effort to allow us to also modify the 96 B-52Hs for cruise missile carriage should we choose to do so. This option will be available to us beginning in 1984.

The Air Force believes that B-52s will serve as efficient and economical cruise missile carriers well into the 1990s. Nevertheless, because of the importance of the Air Launched Cruise Missile, we need to allow for the possibility of unforeseen problems with the aging of B52s, as well as for the possibility that we might need a larger force of ALCMs than can be carried on those aircraft. To provide this hedge we have recommended advanced development and flight demonstration of a new Cruise

---

One of the major segments of the nation's deterrent strength is the manned element of the strategic TRIAD, the bomber force composed of Boeing B-52s, some of which were introduced to service more than two decades ago—yet may still be in service two decades hence. In the following article based on a recent speech, Lieutenant General Kelly H. Burke, USAF Deputy Chief of Staff, Research Development and Acquisition, expresses the Air Force's views and plans for keeping the manned bomber/missile launcher a viable part of the United States' strategic force.

General Burke



Missile Carrier Aircraft. In this regard, we have initially focused our efforts on evaluating a B-1 derivative which we have termed the Strategic ALCM Launcher, or SAL. Adequate funding has been programmed to conduct a flight demonstration in fiscal year 1982. We plan to convert the number three B-1 to a cruise missile carriage configuration and actually launch cruise missiles from both internal and external launch points as the culmination of this demonstration.

During this period we will also complete sufficient advanced engineering design on this B-1 derivative to allow us to move quickly into full scale engineering development should the need arise. This advanced development program would give us good confidence in the SAL design and would protect an early initial operational capability at least through fiscal year 1982.

Our evaluations to date convince us that the ALCM currently in the final stages of development will be a highly effective weapon system and will be able to cope with any defenses the Soviets are likely to deploy during the 1980s.

We have every expectation that the Soviets will make strenuous efforts to counter the ALCM and no doubt, given enough time and money, they will achieve some degree of success. To prepare for that eventuality we are already working, under our advanced cruise missile technology program, on the second generation cruise missile.

My guess is that the Soviet's first efforts likely will be toward attacking the cruise missile carrier before the ALCM could be launched. The best counter to that threat would be to reduce the exposure of the carriers by providing longer range to the ALCM. Consequently, our priority effort for this program is the development of more efficient engines and more dense fuels to provide extra range. In addition, we are exploring alternatives for enhanced survivability of ALCMs through reduced radar cross sections, lower altitudes, higher speeds, and avionics innovations.

The case for the manned penetrator is more complex than for the cruise missile, but no less compelling. First, the inclusion of a consequential force of manned penetrators precludes the Soviets from narrowly tailoring their air defenses to cope only with ALCMs. But more importantly, an aircraft capable of penetration is also capable of performing—and performing well—in a host of varied roles, including both nuclear and conventional scenarios.

In fact, we tend to confuse the issue by calling such an airplane a bomber or a penetrator. The penetration mission requires an aircraft that can fly long distances, that can carry large, diversified payloads, that can provide self-contained target acquisition and weapons delivery, that can defend itself reasonably well against sophisticated air defenses, that can be reused, and most importantly, that can provide on-scene human judgment throughout the mission.

An aircraft with those characteristics provides the flexibility and responsiveness not available in any other aircraft system and is useful across the entire spectrum of conflict. Accordingly, rather than referring to such an aircraft by overly-confining terms such as "bomber" or "penetrator," it can be more accurately described as a Long Range Combat Aircraft—a name that conveys the full sense of its broad capability.

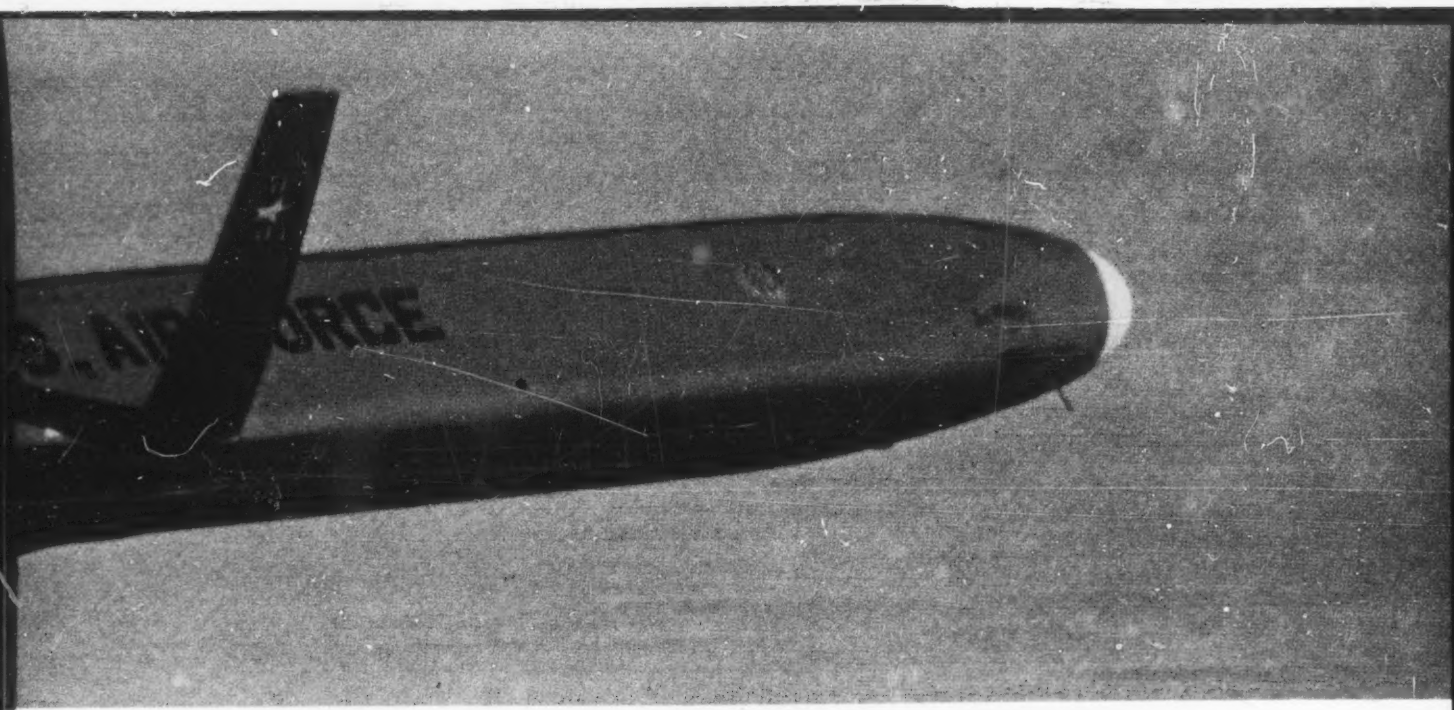
The B-52 is a Long Range Combat Aircraft, the last of a long line we have built. While B-52s are likely to be adequate cruise missile carriers well into the 1990s, this ability to perform more stressful roles will be eroded much earlier. Accordingly, the Air Force believes the country will need a new Long Range Combat Aircraft for the 1990s and on into the 21st century.

The first step toward the goal of such an aircraft is for the Air Force to do the really hard thinking concerning the concept for such an aircraft—what should be its capabilities and how should we employ it in a future that is difficult to predict. We've been doing that kind of thinking for some time and our understanding of this requirement, while still evolving, is much more sharply focused than before.

The second step is for us to evaluate existing technologies and assess the prospects of new technologies to help us understand how such an aircraft could be optimally designed.

Toward that end, we have three relatively small but important programs. The first of these is the bomber penetration evaluation program which is actually the final step in the completion of the B-1 research, development, test and evaluation program. In this program, we are attempting to gather every bit of useful data possible to learn all that there is to learn from the $6 billion and 10 years we have invested in the B-1.

To do that we will fly the number four B-1—the only one with full mission equipment, including defensive avionics—in an operationally realistic environment against all manner of threat radars, aircraft and missiles. From those flights we expect to measure the incremental contributions of



▲ Recently selected as the Air Force's Air Launched Cruise Missile is the Boeing AGM-86B. The first B-52G cruise missile carrier squadron will become operational in December 1982.

One of the four Rockwell International B-1 bombers is being modified as an advanced Strategic ALCM Launcher. Flight evaluation is planned for 1982. ▶

the various aspects of penetration to mission success—the relative value of low level high-speed flight, of reduced radar cross section, and modern reprogrammable electronic countermeasures equipment.

Over the years, bomber studies have reached markedly different conclusions because of wide variance in the assumed contribution of these factors. Hopefully, the empirical data we gather in the fully mission-equipped B-1 will let us narrow that variance and increase our confidence in such studies.

Our second technology program, called strategic bomber enhancement, is directed toward evaluation and demonstration of the key technologies that would be applicable to new weapons systems and subsystems for all elements of the air-breathing leg—including of course, a new Long Range Combat Aircraft should we decide to build one.

High on our list of hardware explorations is radar absorbing material to reduce radar cross sections, which would improve survivability against both surface-to-air missiles and look-down, shoot-down interceptors. Concurrently, we will be looking at modifications to engine technology to reduce the infrared signatures as well. And we are also looking into the more promising airframe and avionics technologies, including variable camber airfoils and digital flight control systems.

The final technology effort supporting the air-breathing leg is a broad based program in the electronic warfare and technology area. This program evaluates and demonstrates new technological offerings for passive and active electronic countermeasures as well as for infrared and optical counters.

Included among the more interesting and significant recent developments are the Doppler tail warning radar—which can detect very high velocity, low radar cross section missiles fired at our B-52s and automatically actuate appropriate countermeasures against them—and a whole new generation of infrared flares which can be tailored to match specific engine infrared signatures.

That is a very quick summary of where we are and where we think we are heading with the air-breathing leg of the strategic TRIAD. For the near term, our major efforts will be on bringing the ALCM into service and making sure we provide it with a suitable carrier aircraft. Beyond that, we will be prepared to introduce a more capable second generation cruise missile before evolving Soviet defenses pose an unacceptable threat to the first generation ALCM.

We will also be working hard to hone the arguments and to develop the technologies to support what we have called a Long Range Combat Aircraft, not only for the strategic penetration role but for use across the entire spectrum of nuclear and conventional scenarios.

With this approach, we hope to insure that the air-breathing leg—the most flexible and responsive element of our strategic forces—remains strong and robust into the next century.

THE U.S. TAX STRUCTURE:

REGINALD H. JONES

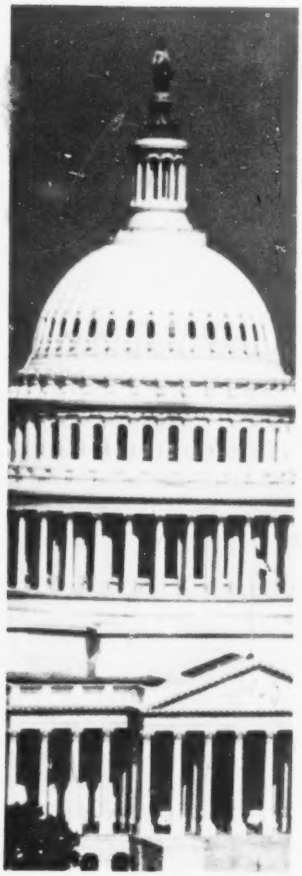
The following is an excerpted version of a speech to the Continental Bank Conference on Taxation delivered by Reginald H. Jones, Chairman and Chief Executive Officer, General Electric Company

It would be impossible to overstate the impact of the tax structure on the United States economy. When federal taxes take more than half a trillion dollars a year out of the income of individuals and businesses, and state and local taxes lift another quarter of a trillion, the sheer volume of dollars extracted for politically determined purposes makes taxation a major concern for all of us. Taxes are one of the fastest growing costs of living in the United States.

How those taxes are raised—who pays and who does not, and how that affects the pace and direction of economic activity—is a decisive factor in the shaping of our national destiny.

So it is not too much to say that the tax structure, and particularly the over-arching federal tax structure, will be either an entry or a barrier to the kind of future that we want for this country.

While some of our fellow citizens would not be averse to a future in which we all return to nature and smoke grass to forget our worries, most of the public seems to want a future distinguished by rising standards of living, energy abundance, and a dollar that's still worth a dollar when it's time to go on pension. This is not an unreasonable aspiration, but it's not going to come about unless we begin to address the underlying problems.



An Economy in Trouble

The U.S. economy is beset by double-digit inflation. We don't know where our energy will come from, but we do know it's going to cost more than ever before. We're running chronic trade deficits, the dollar is still in trouble, our productivity gains have slowed down to the vanishing point, and our industrial machine is aging fast. The labor force is growing faster than our ability to create jobs. And we are in a recession.

The reasons for this sour turn of events are complex and not wholly of our own making. But certainly one very big mistake we have made is to allow our tax structure to become a barrier to capital formation. By any measure—compared with other countries, compared with our own past performance, or compared with our future needs—the United States has not been investing enough of its output in new technology, new ventures and new plant and equipment.

Barriers to Investment

A businessman considering an expansion of capacity or a new venture must feel some assurance that his return will justify the investment. The "hurdle rate"—the minimum predictable return at which he will make the decision to go ahead—has been going up as inflation raises the cost of capital and the risks involved. Meanwhile, real return on

ENTRY OR BARRIER TO THE FUTURE?

investment has been declining for the past fifteen years, under the pressure of inflation and taxes.

And looking to the future, the businessman sees nothing but uncertainties. His energy costs are unpredictable. Soaring inflation makes his labor and materials costs a matter of guesswork. A regulatory bureaucracy that seems totally oblivious to costs keeps piling on more mandated expenditures that contribute nothing to profitability. Environmentalists make most major projects subject to capricious interruption and delay. Government stop-and-go policies have produced several credit crunches and three recessions in the 1970's—not exactly reassuring. And fierce foreign competition and the threat of price controls make the businessman wonder whether he can recover enough of his costs in the future to justify the investment.

With all these barriers to investment, we certainly do not need a tax structure that bleeds off profits at an excessive rate and discourages savings and investment.

Savings

Personal savings in 1978 amounted to $72 billion, but corporate savings, in the form of retained earnings and depreciation, amounted to $169 billion. In other words, the volume of real corporate savings is about 2 1/2 times as large as personal savings.

From a tax policy standpoint, this suggests that legislation which increases business savings offers unusually good leverage to lift capital investment. Business savings can be quickly affected by corporate tax rates and capital cost recovery provisions. And since the increased savings go directly to business, there is a good probability that they will most rapidly find their way into the investment stream.

Thoughts on Tax Structure

Thinking of long-term changes, one possibility for restructuring the tax code—admittedly a revolutionary idea—would be a progressive expenditure tax to replace the personal income tax. It would be comparable to an income tax except that the tax base is annual family or individual consumption rather than income. Thus people would be taxed on what they take out of the economy, but not on what they put in as savings and investment.

The much-discussed value added tax might also emerge as part of a future tax system. It seems to me that it might be used here as an effective replacement for the corporate income tax.

The third element of a future tax system could be a negative income tax to replace the cumbersome and wasteful welfare system.

This three-legged stool—expenditure tax to replace the personal income tax, value added tax to replace the corporate income tax, and negative income tax for the poor—is a possibility that might bear investigation as we work with a Congress that is evidently willing to think long thoughts about the tax structure.

What's Needed in 1980

The problem is to build up the supply side of the economy. A proposal that would help build the supply side might include a $7 billion tax reduction for business along with an $18 billion cut for individuals that encourages savings and investment. Let's look at the opportunities on the business side.

Here, a combination of improved capital cost recovery allowances and reduced corporate tax rates would be the best package both economically and politically.

One program that has already achieved substantial bipartisan support in both houses, and from both large and small business, is the (10-5-3) Capital Cost Recovery Act. It would improve the investment tax credit and provide fixed recovery periods for investments in productive assets in lieu of the present system of recovery periods based on the outmoded "useful-life" concept, which is entirely inadequate in inflationary times. Such improved capital recovery allowances would boost business savings and thus provide funds for increased investment in productive facilities.

Additionally, there should be an across-the-board cut in the corporate income tax rate—say 1 or 2 points. Such an action, which would benefit labor-intensive as well as capital-intensive companies, would help create jobs and economic activity by making expansion funds available.

The Productivity Challenge

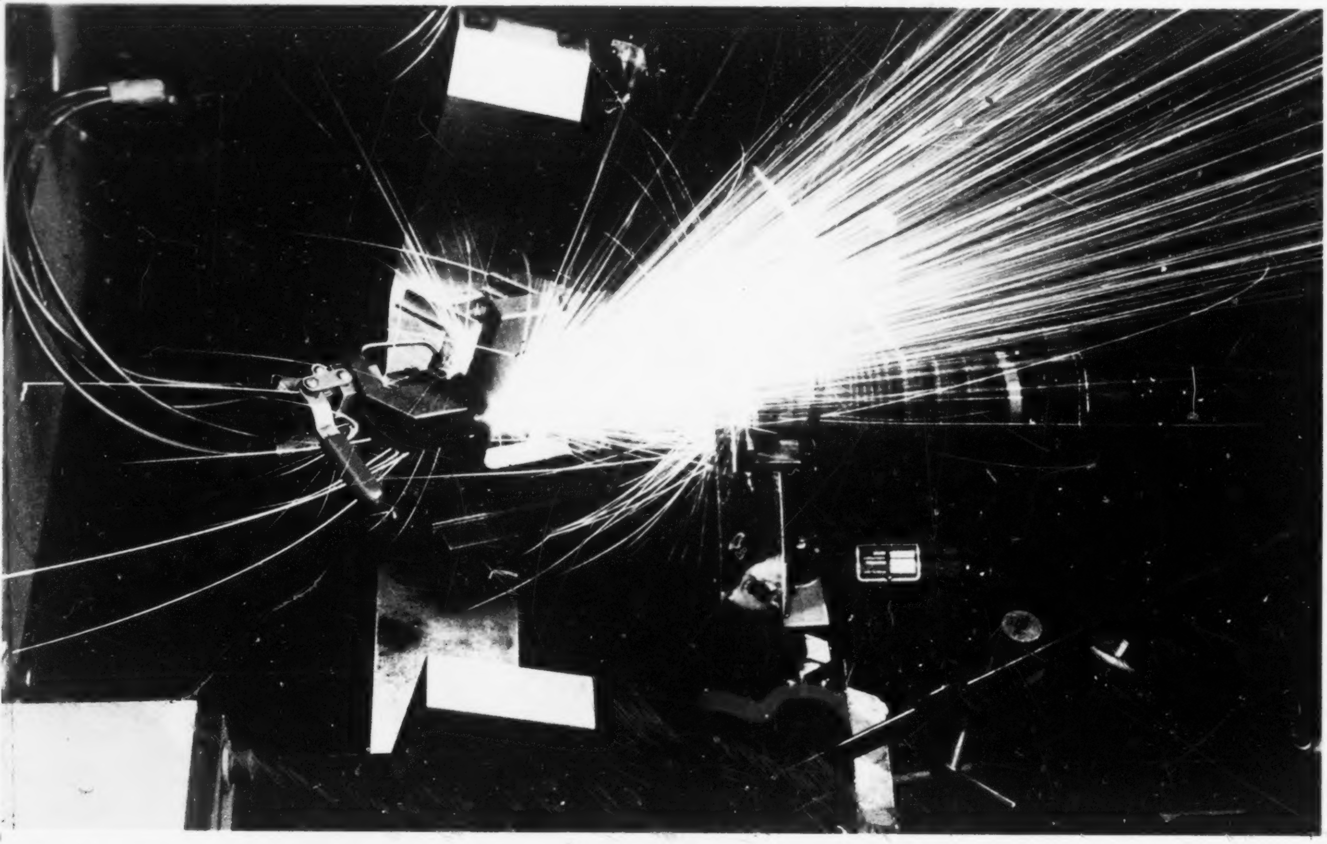
In the 1970's, this country's real gross national product rose at an annual average rate of 2.8 percent—down from 4 percent in the 1960's. The main reason for the slowdown is that during the 1970's, productivity growth was less than half what it was in the 1960's. Most of the increase in our gross national product came from growth in the labor force.

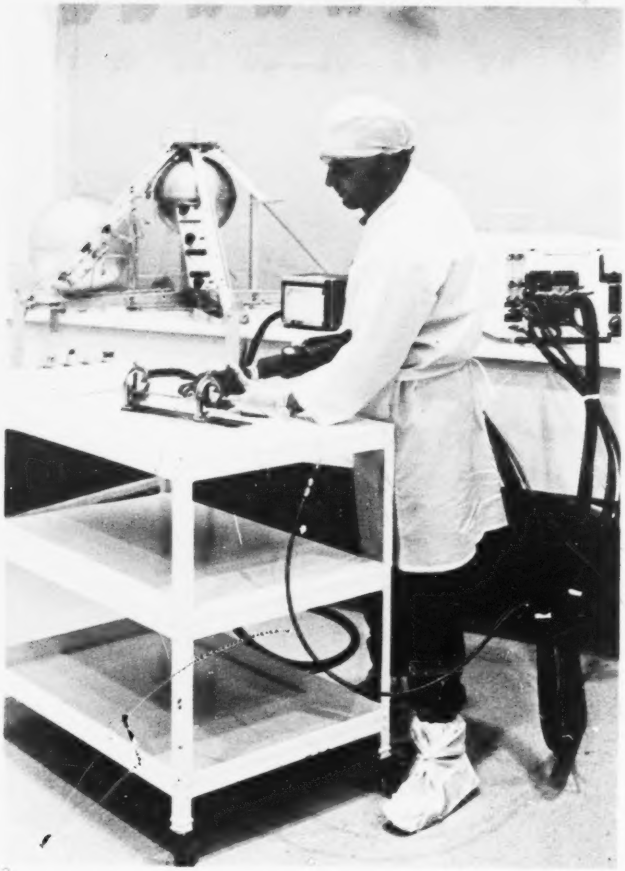
In the 1980's, demographics tell us that the labor force will grow more slowly. Thus we must have increased productivity gains, and they must come from increased investment in new technologies and new equipment. Otherwise we will see a continued downward drift in our national economic growth rate—along with chronic inflation, chronic unemployment, and a further decline in our national position.

Changing the tax structure will not, by itself, be enough to assure the needed level of business investment. There are so many other uncertainties facing business decisionmakers that we may still be unable to generate the necessary confidence to trigger a boom in capital spending.

But with all these other barriers to investment, surely we must not allow the tax structure to stand in the way. Changing the tax structure to encourage a higher level of capital formation is a fundamental requirement.

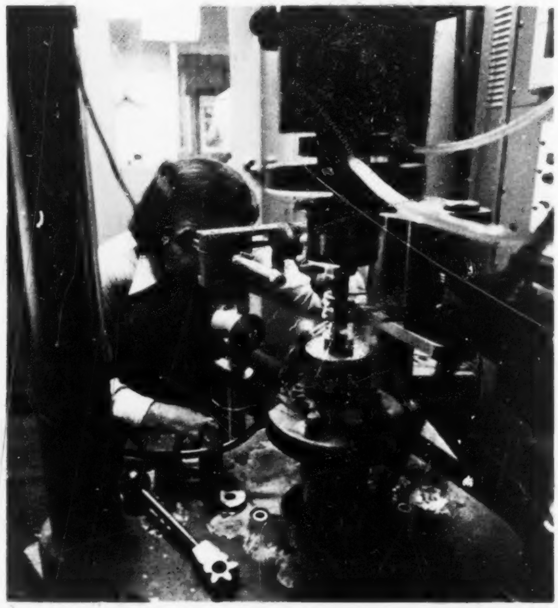
And furthermore, it's do-able. The productivity challenge is widely acknowledged. The Administration and the Congress are convinced of the need for more capital formation and ready to act. Now is the time to move, decisively, on this long-neglected task.





TOOLS
of the Aerospace Trade

Since World War II, the aerospace industry has experienced enormous change in both product line and the methods by which the products are manufactured. Once limited to aircraft, the product line has expanded to embrace such flight systems as missiles, spacecraft and space launch vehicles. The airplane itself today bears only casual resemblance to its pre-war forebears. ■ In all types of aerospace vehicles, there has been continuing demand for increased performance, accomplished by design advances in shape, structure, propulsion and onboard equipment. These advances dictated corollary changes in manufacturing techniques and facilities, necessitating large-scale industry investment in new, automated tools and equipment to handle new materials, compress production time, increase productivity and maintain product quality. What it takes to build a modern, high-performance aerospace system is exemplified on these pages by a representative sampling of manufacturing tools, some of which are as sophisticated as the products they turn out.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1. A Pratt & Whitney Aircraft laser system drills holes of various diameters in jet engine turbine vanes. The drilling laser is linked to computerized equipment which assures constant location of the holes from part to part, permitting faster drilling by relieving the operator of the many hole-locating steps normally required.
2. In a clean room atmosphere, an RCA Astro-Electronics technician is using an induction brazing machine to join fittings to tubular components. The machine uses radio frequency energy to generate heat for brazing; temperature is automatically monitored and precisely controlled.
3. Components of a Detroit Diesel Allison gas turbine aircraft engine are being tested by sophisticated equipment to determine their ability to withstand metal fatigue over a long period of engine operation.
4. Manual bending of tubes—for hydraulic, air, cable or other lines—is extremely difficult and inconsistent. Used to shape tubes for the L-1011 TriStar, this computer-controlled "Vector Bender" at Lockheed-California Company's Burbank plant bends tubes to perfect specifications.
5. This Magnetron Sputtering System automatically deposits layers of thin film metals for integrated circuit production. The unit shown is in use at Westinghouse Electric Corporation's Defense & Electronic Systems Center.
6. Hamilton Standard Division of United Technologies uses numerically-controlled machining equipment to build jet engine fuel controls from raw components. Manufactured with speed and accuracy, the resulting product is a reliable, lightweight control rugged enough to withstand the vibrating, red-hot environment of the jet engine.

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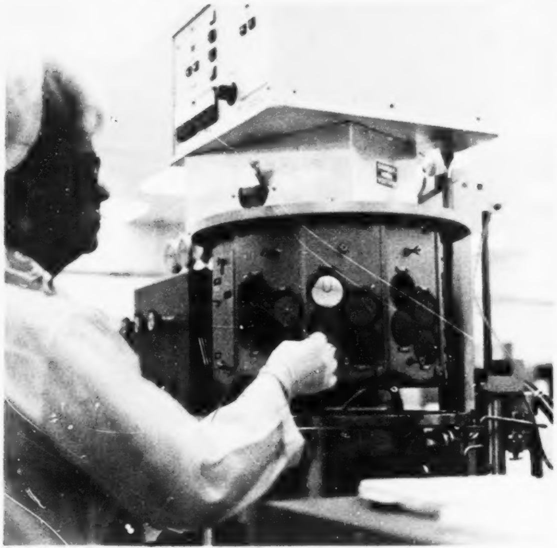
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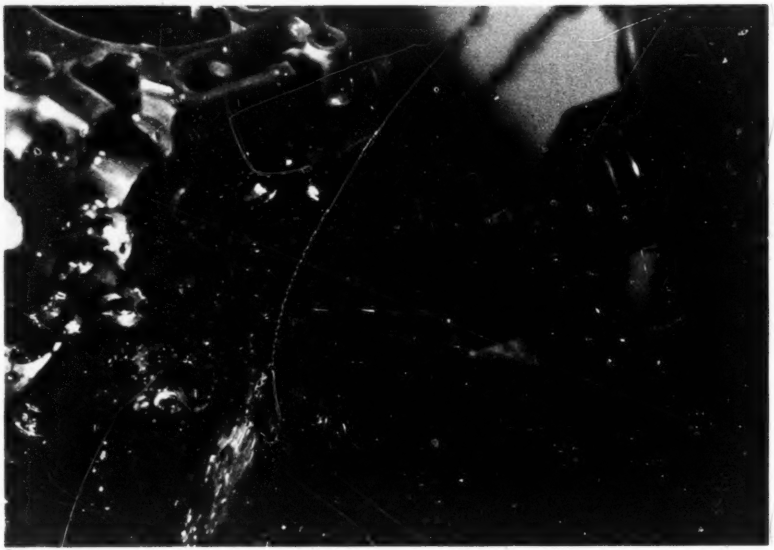
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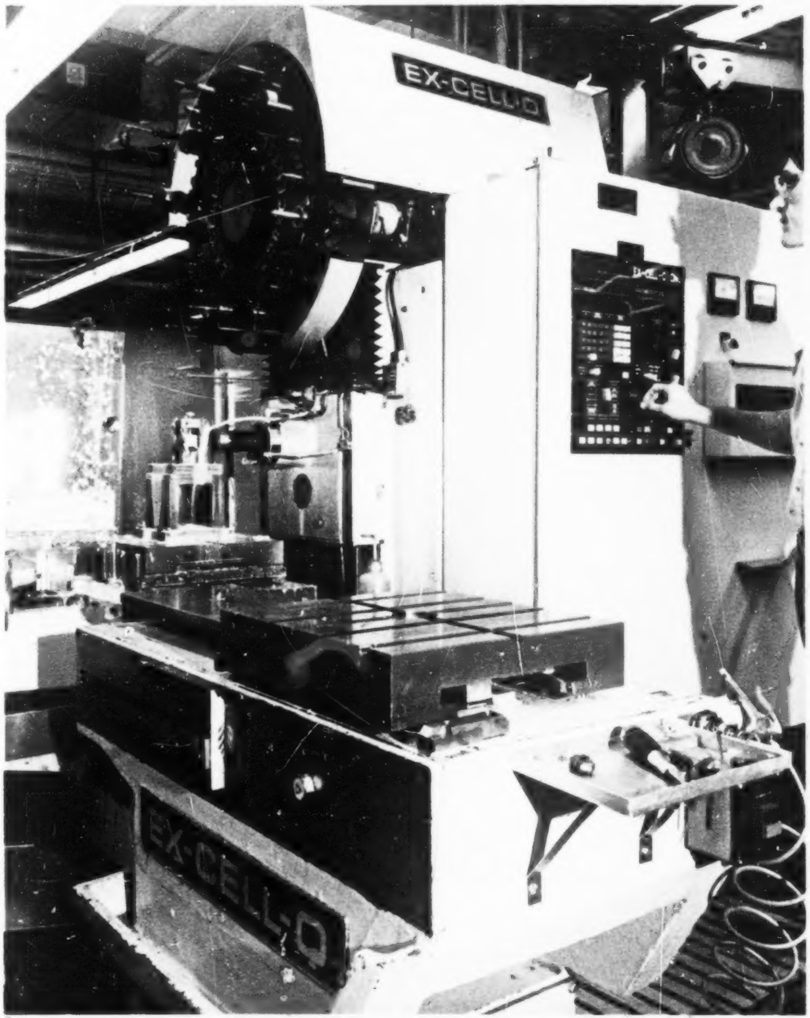
7. A Hughes Aircraft Company employee is using fiber optic cable to check the optics of the Army's Ground Laser Locator Designator, a device that will enable forward observers to mark targets for laser-guided weapons. The system requires precision assembly and measurement; the fiber optic cable, used like a tiny flashlight, provides a high intensity light source for examination of hard-to-reach parts.

8. Sperry Flight Systems employs a bank of computer-controlled machines to perform high-speed drilling and routing of aluminum stock in production of instrument packages and airborne computer chassis. Tool selection and positioning of the work is operator-controlled through a computer console.

9. Gates Learjet Corporation has adapted an auto industry technique: use of a mahogany master model as a basis for molding production tooling for the company's 54/55/56 business jets. The mahogany master comprises five fuselage sections, mounted on rails and separable for striking molds. It offers greater skin-line accuracy and better durability than conventional plaster masters.

10. Rosie the Riveter's hand gun is being replaced by automated systems which precisely locate the rivet point, bang home the rivet and smoothe the riveted surface, saving time and money and improving the end product. In the photo, automatic riveting machines are preparing helicopter subassemblies at Sikorsky Aircraft Division of United Technologies.



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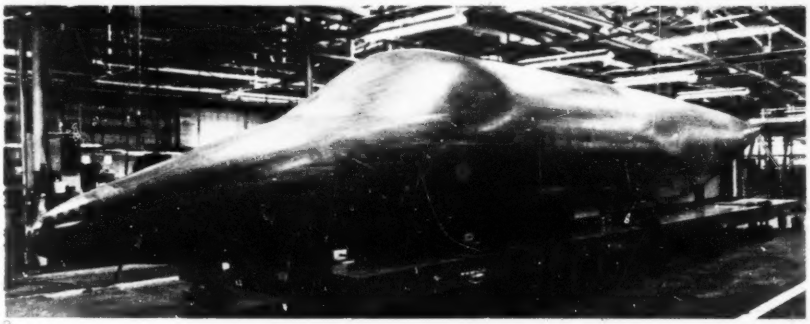

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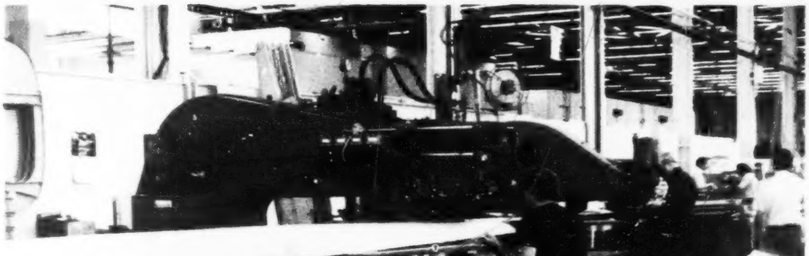

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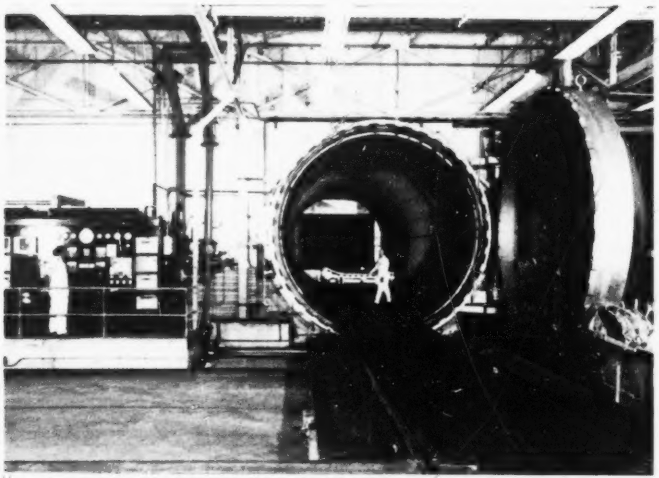

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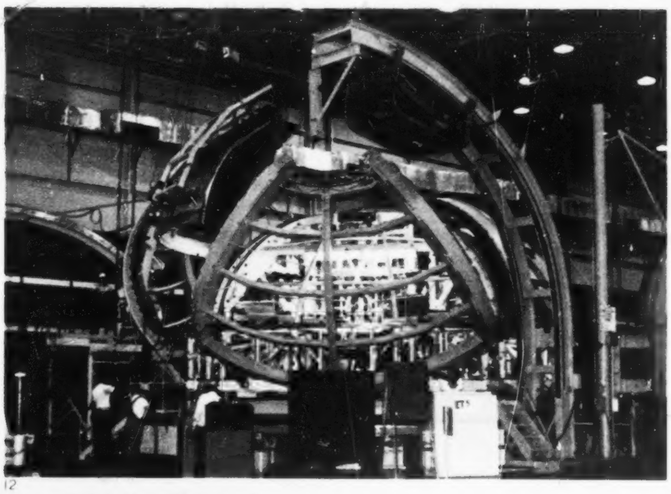

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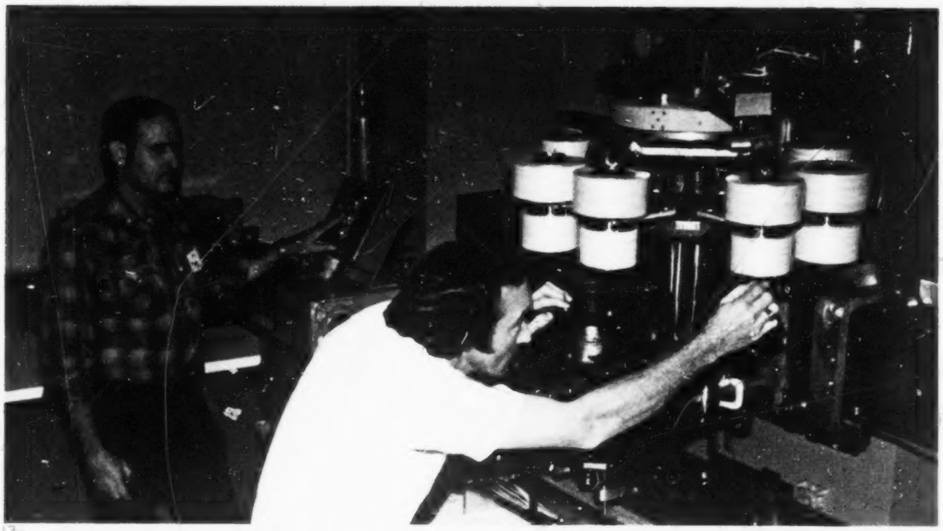

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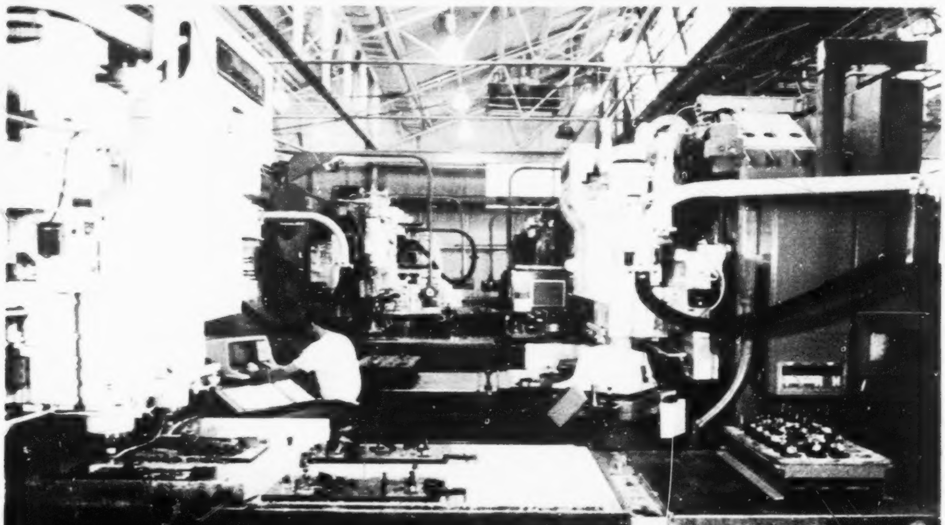

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11 Some modern manufacturing techniques involve bonding metals or curing composite materials under controlled high temperatures and pressures. Such operations are conducted in huge autoclaves such as the Vought Corporation chamber pictured.

12 A unique clamshell-like tool, designed by Martin Marietta Aerospace and in operation at the Michoud Assembly Facility, is used for fabricating dome caps for the hydrogen and oxygen tanks within the mammoth external tank of NASA's Space Shuttle. In the tool, four quarter panels are positioned, trimmed to thousandth-of-an-inch tolerances, then arc-welded into a complete dome. To assure perfect welds, every inch of the completed section is x-rayed to detect even the most miniscule flaw.

13 This complex equipment was developed by Bell Helicopter Textron for manufacture of the company's new all-composite medium helicopter rotor blade. It automatically winds filament around the blade spar, enhancing production efficiency and improving product quality.

14 Rohr Industries, Inc. uses numerically-controlled Bridge Mills for heavy duty shaping and machining of steel and titanium parts, such as aircraft structural components. The monitoring operator is advised of the machine's performance by a readout on the computer terminal.

SPACE MANUFACTURING: A New Challenge

by Karl G. Harr, Jr.
President, Aerospace Industries Association

As we commence the final two decades of the 20th century, we stand on the threshold of an entirely new capability for extracting further, even larger-scale benefits from space. The operational advent of the Space Shuttle and its Spacelab component will provide routine access to space, an orbital laboratory for advanced experimentation, and a foundation for construction of habitable facilities in orbit. This will make possible a significantly broadened range of space operations, including the initial steps toward manufacturing in space, which offers potential for social and economic benefits of immense order.

I use the word "manufacturing" with some hesitance: I'm afraid it conjures up in the lay mind a crackpot notion of huge assembly facilities in space cranking out airplanes or automobiles or refrigerators. The space industrialization concept, of course, does not envision use of the space environment for jobs better done on Earth; rather it involves taking advantage of some of the unique characteristics of space—particularly weightlessness and airlessness—to do useful work which cannot be performed as well, or at all, on Earth. Although commercial feasibility has yet to be demonstrated, early experiments—in Skylab, Apollo-Soyuz, in sounding rockets and ground-based facilities—have indicated good possibilities for in-space production of certain high-value-per-pound items produced under gravity-free, near-vacuum conditions.

Pharmaceuticals, for instance. On Earth, the presence of gravity limits the quantity of pharmaceuticals that can be produced from a given amount of starting material and, most importantly, Earth gravity adversely influences the purity of the end product. But in the microgravity environment of space, it is theoretically possible to process in greater quantities a whole new class of high-purity pharmaceuticals, enabling greatly improved treatment of a variety of diseases.

Similarly, some materials that cannot be mixed under surface gravity conditions can be mixed in the space environment. This opens up the possibility of producing new metal alloys or composite materials far stronger, lighter and more temperature-resistant than anything currently produced. About 150 possibilities for space-manufactured products have been identified—new products that cannot be made on Earth, products far superior to those now made on Earth or, odd as it may sound, products capable of less expensive processing in space than on Earth. That's only a starter; almost certainly the potential product range will expand with greater experience in space processing research.

Thus, we may be on the verge of another giant step in industrial development. Its accomplishment will demand significant technological advancement, but the experience of the past two decades suggests that our technological capability is adequate to the challenge. The limiting factors to our realization of the space industrialization potential are more likely to be the practical considerations of investing capital in high risk ventures.

The space product must compete, in terms of risk related to anticipated return, for company R&D funds with other, more conventional investment opportunities. Before a company can commit itself to the investment, it must establish that the contemplated development has a good chance of success; that the resulting product will be much more than an incremental improvement over existing products; that it will have a very high value per pound to enable recovery of the large outlay; and that there is, or will be, a market.

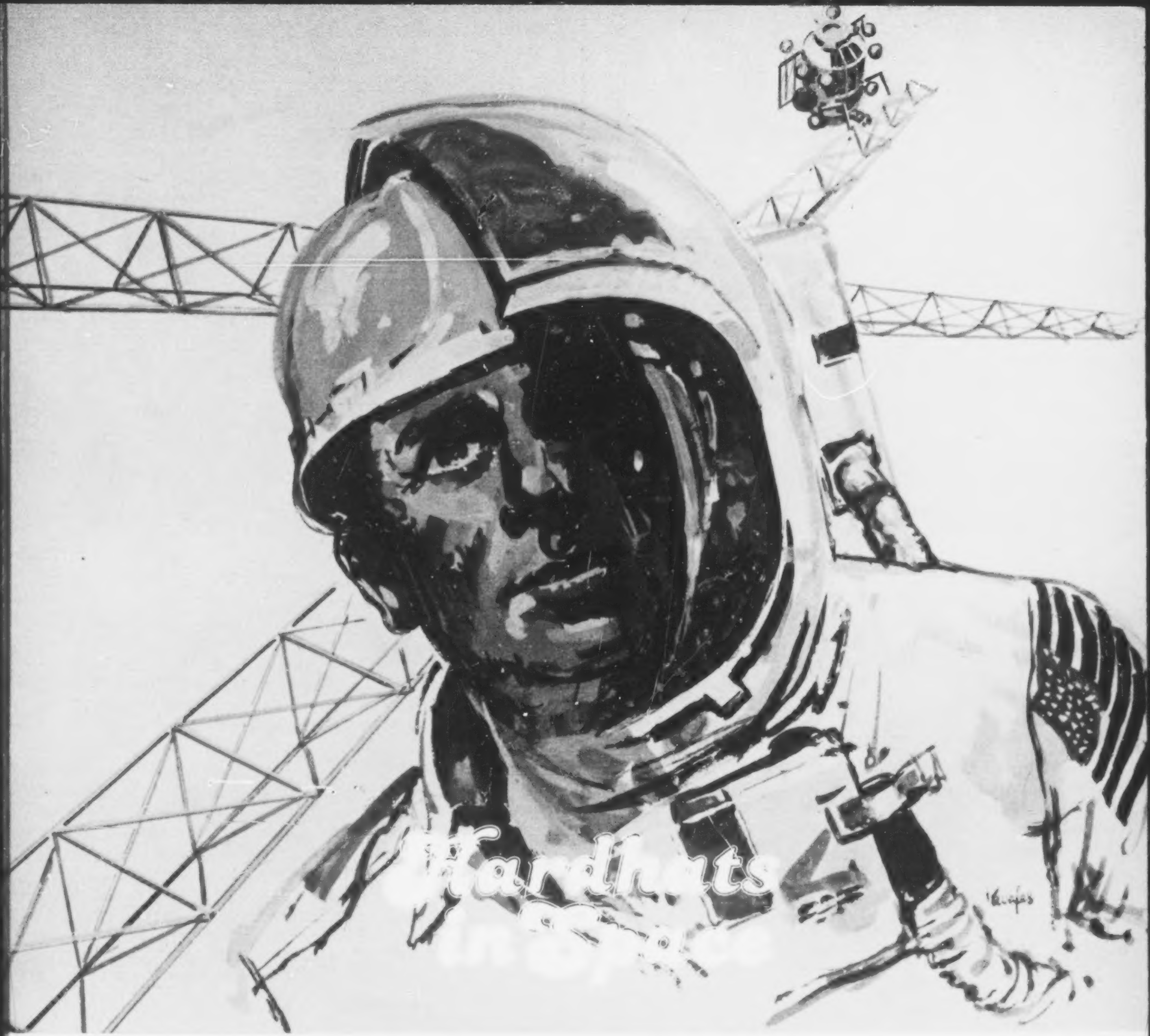
But to verify that a product opportunity actually exists, it will be necessary to conduct extensive experimentation in the space environment. That will require very heavy funding, far greater than that normally encountered in industrial R&D and well before commercial feasibility has been established. The combination of high risk and large outlays may discourage many potential developers.

A valuable stimulus to space industrialization is NASA's Joint Endeavor Program, under which NASA and a private firm each agree to fund specific portions of a research effort. This reduces to some extent the front-end money a company must put up to conduct experiments and verify product potential in orbit. It is an important step in the right direction, but even with joint endeavors, the costs of space product development will still be high. Before we can expect extensive space commercialization, there must be some provisions for reducing the degree of risk or increasing the potential rate of return—for example, tax-free status on space product revenues for a certain time, increased allowable deductions for R&D, increased investment tax credit or decreased depreciable equipment life.

Whatever form they may take, there is need for stronger incentives to private sector participation. The government should recognize that space industrialization is something more than a simple extension of the normal innovation process. Rather it involves moving into an alien environment, where development costs are substantially higher, to explore unproved processes in the hope of developing products for which there is as yet no solid market information. The risks are greater, the return more uncertain, and the considerations of product development are vastly different—factors which should warrant special forms of incentivization in the interests of national benefit.

Given adequate incentives, I am confident that private industry will respond to the opportunity that space industrialization presents. It is important that we do so—important to our economy in terms of new industries, new product lines and new jobs; important to our continued preeminence in science and technology; and important from the standpoint of international competition, because other nations are already moving forward in this area. Our nation, which pioneered space commercialization with communications and other satellites, cannot afford to abdicate its leadership now that the time for reaping the harvest of space is approaching.

This article is a condensation of a speech by Mr. Harr to the American Astronautical Society's Eighteenth Goddard Memorial Symposium.



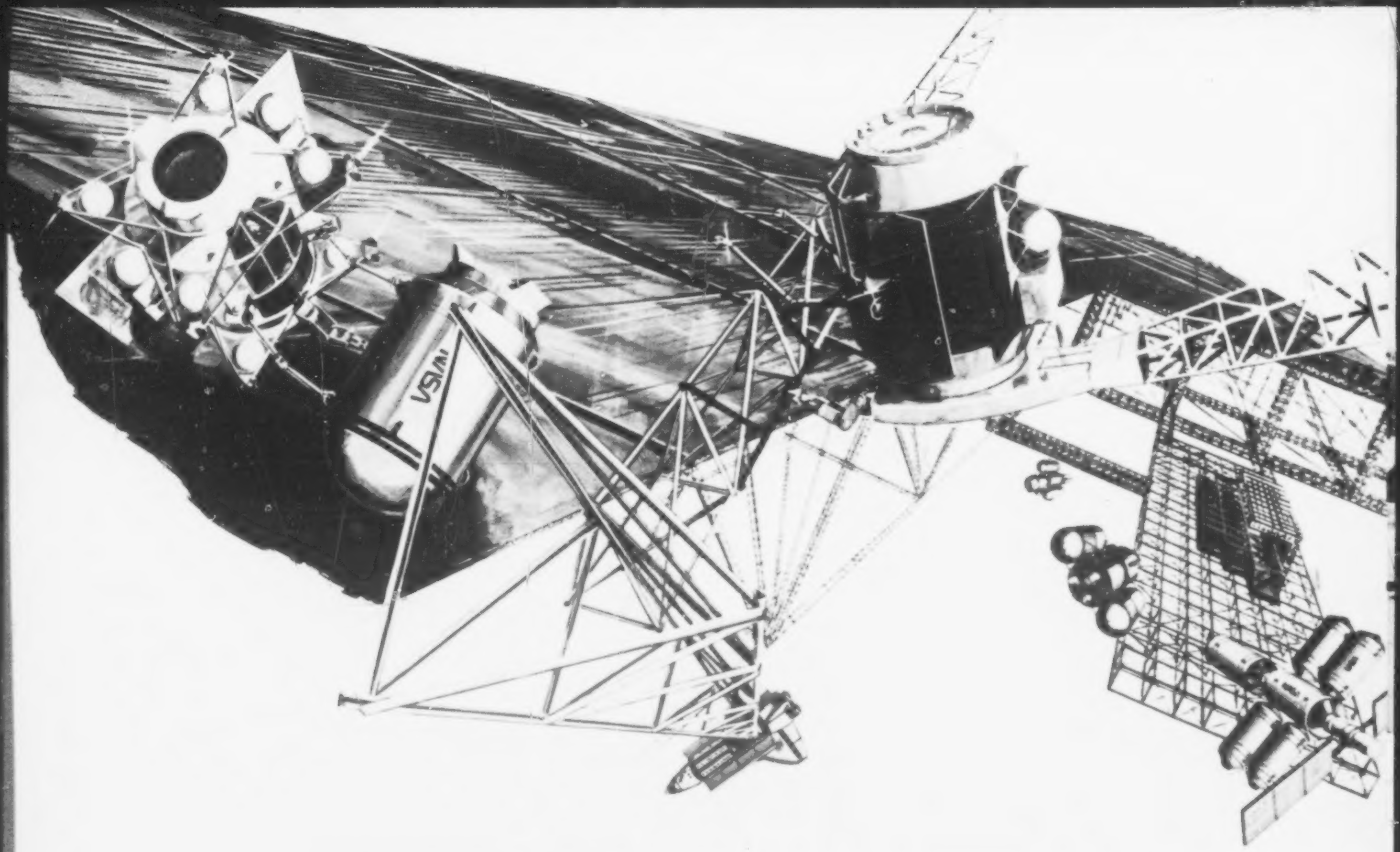
Hardhats in Space

Space construction, to begin in the latter years of this decade, is occupying the attention of a broad segment of the aerospace industry. Representative of the studies and hardware development activities being conducted by industry firms is this summary of space construction concepts developed by Grumman Aerospace Corporation. The author, a former Apollo astronaut, is the company's Vice President—Space. The article is reprinted from Grumman Aerospace's HORIZONS.

by FRED W. HAISE, JR.

Man, the consummate builder, whose pyramids and coliseums, skyscrapers and suspension bridges have spanned the history of civilization, may soon take his tool box and lunch pail into space. By the end of this century, only 40 years since *Sputnik*, hardhats will be commuting to sprawling job sites in Earth orbit. The prospects are even more spectacular than the lunar landing. The benefits to mankind . . . incalculable.

Free of the effects of gravity, astroworkers will be able to assemble structures weighing from thousands to millions of Earth pounds. On the drawing boards now are such concepts as space factories capable of turning out mate-



Space construction circa Year 2000. At left is a free-flying work vehicle grappling a utility module; lower center, a Shuttle Orbiter delivery vehicle; upper center, a manned, pressurized "closed cherry picker"; next to it, a manned orbit transfer vehicle; at far right, a space construction base created by mating several pressurized Shuttle-delivered modules.

rials with unique properties only theorized before, laboratories creating pharmaceuticals impossible to produce on Earth, or a series of solar power satellites that might one day contribute to our energy needs. Indeed, human invention in the next few decades could harbinger a new industrial, social, and economic revolution.

For those persons privileged to take part in space construction missions, it will be a truly unique experience. For one thing, the view from a work station in Earth orbit is nothing short of spectacular, far exceeding the scene from atop the highest building or bridge tower here on *terra firma*.

The total quiet at the space construction site will also take the construction worker some time to get used to. In the almost perfect vacuum of space, virtually the only sounds the hardhat will hear will be those coming from his headphones and from movement within the spacesuit or other vehicle within which he (or she) is enclosed. A variety of construction machines will be in action, beams produced and capped, joints pressed and clamped into place—but in the airless environment, none of the usual banging and clanging sounds. Nothing but silence, complete and awesome, but strangely comforting as well.

There will be other startling contrasts, such as the change from the blindingly bright sunlight and reflections from shiny surfaces to the blackest darkness imaginable at the instant the construction worker steps into shadow. And then there is the free-floating world of zero-gravity which, unlike the brief periods of free-fall induced in test aircraft, is the natural, constant state in space. Aside from the unusual sensations it causes in humans, weightlessness creates special problems for the construction worker, particularly in maintaining one's position relative to the job at hand. But there are technological solutions aplenty for problems such as these.

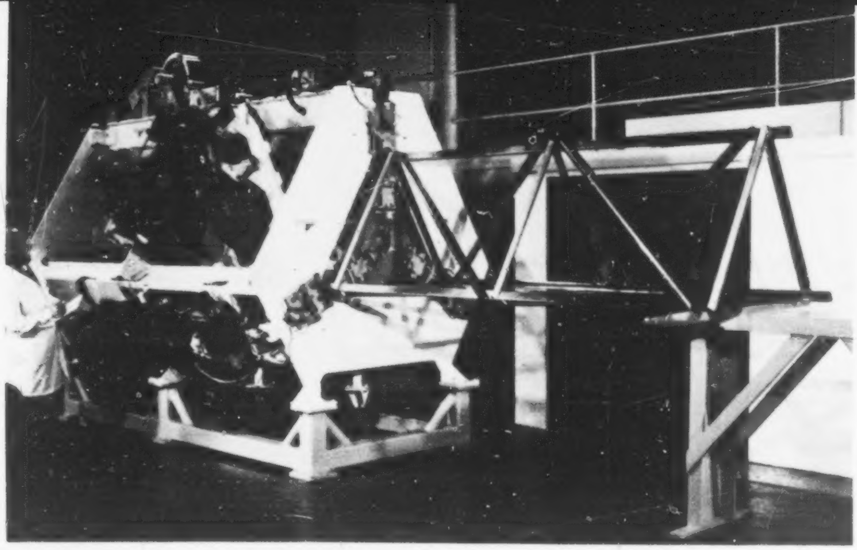
A cardinal rule for the space construction worker will surely be *Always use a tether!* for himself and for all tools and accessories. A more beneficial effect of weightlessness, however, will allow a worker to assemble enormous structures—some of them stretching for miles—that would collapse of their own weight under the force of gravity on Earth.

Plans for Space Construction

In the next two decades, several missions are tentatively planned that involve the erection of large vehicles or structures in Earth orbit. Included among these are large demonstration models of future solar power satellites which will prove the feasibility of tapping the virtually limitless source of energy in our Sun to furnish electric power to Earth.

Other ventures that will require piecemeal assembly in orbit involve both manned and unmanned space platforms needed to support long-duration flight operations. Also conceived are large space-based antennas, up to several hundred feet in diameter, which would support major civil communication as well as military radar surveillance missions.

It all begins modestly enough with the NASA Space Transportation System, a Space Shuttle which will commute to the orbital construction site and back bringing men and material to the job. The Shuttle Orbiter, with a cargo bay 15 feet in diameter and 60 feet long, can carry a payload of more than 32 tons. And it can support a work crew in orbit a week or more during



The Grumman-designed Automated Beam Builder converts spools of metal into structural beams up to 300 feet long. The machine has been successfully demonstrated on the ground and will be space-tested on an early Shuttle flight.

early space construction demonstration projects.

Construction crews will not have to be astronauts or wear cumbersome space suits to fly aboard the shuttle because its cabin is like that of any commercial jet. In the earliest space shuttle missions, only occasionally would the need come for manned construction work. Indeed, one of these early flights is scheduled to demonstrate an alternate means of erecting large structures in space, in which man will be only remotely involved . . . controlling an electro-mechanical manipulator, inspecting junctures, or making minor adjustments.

Space Antennas

An example of an early large-structure demonstration project is a large lightweight communication and radar antenna measuring up to 300 feet in diameter. One such antenna, designed by Grumman, features a unique self-deployment scheme. Built on earth, the Grumman "wire wheel" space-based antenna would be collapsed and neatly stowed in the orbiter's cargo bay. Once in orbit, the antenna deployment mechanism would be triggered by the crew of the Shuttle, and the huge "dish" would begin to unfold. In a matter of hours, the antenna would attain its fully-deployed shape with all the precision it must have to function properly.

And what would be the incentive for putting up a large antenna in orbit? For one thing, with such large high-gain devices in space, the size and cost of ground receiving transmitter stations can be substantially reduced, while much weaker signals can be received. A 300-foot-diameter antenna, for example, could receive and process signals about one-tenth as strong as those of current satellite systems. The large antenna would focus return signals into extremely narrow bands, allowing localized ground signals to be improved even to the point where wrist radios might become commonplace—50 years after Dick Tracy.

Electronic mail, using the space-based antennas as central receiving/dispatching stations, is another distinct possibility, while as Earth-looking radiometers they could report on worldwide soil and crop conditions. And three-dimensional or holographic TV relayed by the big dishes could bring about face-to-face business or political meetings around the world without the need, expense, or time required for travel.

Public service platforms will eventually group three or more large antennas for several different applications on a single satellite using a structural framework many hundreds of feet long. Potential economic gains would accrue from use of common structure, power, and control systems. This elaborate antenna system, however, would be too large to be built on Earth and transported into space. Instead, it would have to be built and assembled in space. And that kind of construction is where the hardhats fit in.

The Beam Builder

For building large structures in space, the four major steps are beam fabrication, beam assembly, deployment, and final assembly of the finished structure in orbit.

Under contract with the NASA-Marshall Space Flight Center, Grumman has already developed and successfully demonstrated on the ground a full-scale machine that automatically fabricates a triangular one-meter-wide structural beam in varying lengths—the stuff of which near-term space facilities will be built. With beams produced at the rate of 1½ meters per minute, a mile-long spidery structure could be assembled in less than a day.

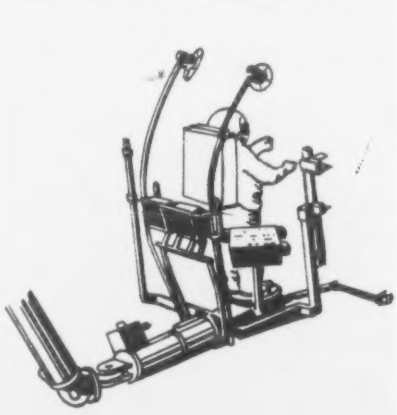
One might understandably question the need for building beams in space. Why not carry them up already fabricated? The answer is a very practical one involving weight and volume penalties . . . and economics. The beams in space, which may reach lengths of up to 300 feet, needn't have the strength and weight to take Earth gravity and launch-acceleration loads and thus can be much lighter if built in zero-g. Then, too, coils of raw beam material can be packaged more densely than finished structure, which cuts down on launch costs.

Because of the absence of gravity, the space beams will be more like a framework than a foundation. Of course, in the perpetual calm of outer space, wind or other weather effects are of no concern.

As plans presently stand, an automated beam machine will be installed in the cargo bay of an orbiter and flight-tested by the mid-1980s. As part of the evaluation, a remote manipulator arm will be used to handle the beams produced in space and to deploy or retrieve spacecraft from the orbiter cargo bay.

Assembly in Space

Once the basic structural beams, the raw material of space construction, are available in orbit they will need to be assembled—as in a giant erector set. In this the astroworker will play a strong



Being developed by Grumman, the "open cherry-picker" is a work station for a space-suited astroworker.

role aided by another Grumman development, the Manned Remote Work Station. Termed an open "cherry-picker," after the hydraulically powered, crane-like vehicles used by earthbound utility and construction companies, it consists of an open work platform attached to the end of a manipulator.

With the open cherry-picker, the astroworker is provided with means for effective body stabilization and positioning and a control-and-display console with controls for the stabilizer, lighting, intercom, manipulator, and other functional elements. Foot restraints hold him in place with arms and torso free to manage the task before him, while a rotary bearing in the platform base allows him to swivel to the most convenient position.

Once space construction jobs reach the scale of, say, a large manned space station or a solar power satellite, the open cherry-picker must give way to a closed-cabin unit in which the astroworker will toil shirt-sleeved. To address this need, Grumman has developed a closed cherry-picker. A pressurized work station with integrated controls and environmental systems, it has two dextrous manipulators—six-feet-long arm extenders—to help the astroworker get at the job.

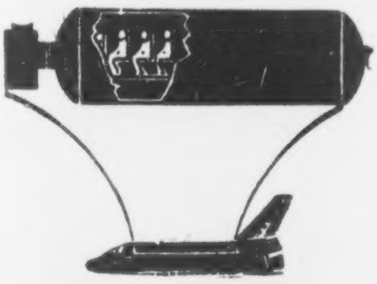
In this closed, shirtsleeve environment, the work will be more comfortable and less tiring, allowing longer work shifts on the large space construction jobs. Special shielding built into the walls of his closed cab will allow the astroworker to stay on the job despite bursts of potentially hazardous radiation that flare periodically from the Sun. Such protection will become essential when the space construction missions move to geosynchronous orbit (some 22,300 miles above the equator) . . . beyond the shielding effect of Earth's radiation belts.

A more elaborate variant of our closed cherry-picker is called the "free-flier." This design reminds one of the Grumman Lunar Module in that it incorporates sophisticated life control and propulsion systems—a true manned spacecraft designed to operate solely in space. It will give the astroworker the freedom to roam the construction site, performing jobs ranging from transporting and connecting beams to rescuing personnel who may become disabled or stranded.

Space Factories

For all the versatility of the Space Shuttle, beam builder, and cherry-picker systems, eventually (perhaps by the late 1980s) the need for more power, staying time, housing, and the cost of larger construction projects will outstrip the early Orbiter-supported demonstration platforms. A more permanent manned construction base in low earth orbit will be needed to overcome these restrictions when the space construction business really starts to boom.

Grumman's space construction studies indicate that, by about the mid-1990s, the first such manned construction bases, or factories, will accommodate small teams of workers for up to 90 days. Later, as many as 500 or more workers will be housed in space. Our engineers envision a semi-automated complex with motel units, a cafeteria, and many of the amenities found aboard an ocean liner.



A modification of the Spacelab, the Work Crew Transporter fits into the Space Shuttle's cargo bay and accommodates 25 astroworkers plus cargo.

In time, a larger, second-generation version of the Space Shuttle will probably be required. Also, the logistics of large-scale construction projects will demand supplementing the Shuttle with a far more prodigious "delivery truck." For this job NASA and industry space engineers have conceived of a liquid-rocket-powered "heavy lift launch vehicle," or HLLV, that can boost a payload of up to a million pounds into low earth orbit.

Once the construction business extends to orbiting platforms at synchronous altitude, a new type of vehicle will have entered the space construction inventory. This is the Manned Orbital Transfer Vehicle, a cargo-and-passenger carrier that will fill a role analogous to that of the Shuttle. It will be a large pressurized craft with propulsion to transfer workers and material from the construction base in low Earth orbit to geosynchronous altitude and back again.

In current thinking, a solar power satellite would be assembled at a factory site in low earth orbit and then transported via a solar-electric propulsion system into geosynchronous orbit. To collect enough solar energy to deliver 5,000 megawatts into the electric power grid on Earth, the operational satellite would be a huge structure about 12 miles long and three miles wide. The manned space construction factory will build the vast solar power satellite in large sections . . . one at a time. As it produces completed structure, the factory moves away, unfurling enormous spooled carpets of solar-cell arrays. Automatically, these are tensioned across the topmost surface of the satellite in position to capture the direct rays of the Sun.

Once a section has been completed, the factory is nudged by manned space tugs (or a system of attached thrusters) into place for fabricating the adjoining section. During all such gigantic construction operations, men and women will continue to fill key jobs—as project scientists and engineers, electrical technicians, maintenance crews, and hardhats. And when the vast space facility has been completed, the astroworker will continue to be needed . . . to keep the solar power arrays working, replacing worn-out cells, laying new arrays, making routine and emergency repairs, and adjusting structural elements.

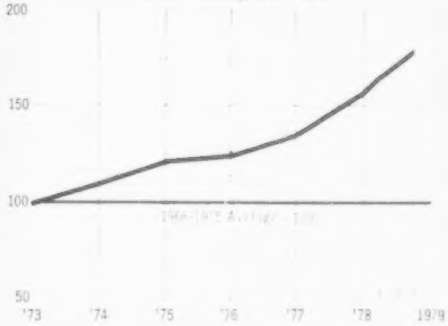
In this manner the huge satellite would eventually be placed in service, perhaps in as little as a year after start of construction. And in a similar way, various other facilities would be built to serve the needs of mankind worldwide: laboratories to develop new life-prolonging chemicals and vaccines; factories producing products with extraordinary qualities; public service platforms for global voice, video, and data communications; and solar-terrestrial observatories for studying the interactions between Sun and Earth which control our climate and weather patterns.

Joining the work force for this grand space enterprise of the next century will be crane-equipped cargo carriers that move about on tracks, fixed construction control centers, work capsules on mechanical arms, and manned free-fliers . . . work stations for a new breed of worker: the hardhat in space.

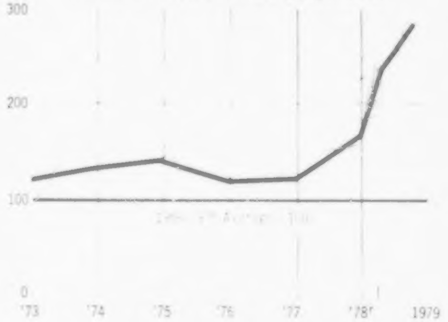
AEROSPACE ECONOMIC INDICATORS

CURRENT

Total Aerospace Sales

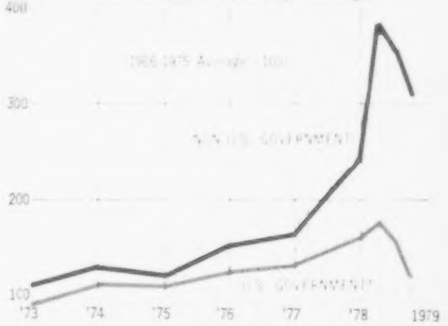


Value of Civil Aircraft Shipments



OUTLOOK

New Orders — Monthly Average



ITEM	UNIT	PERIOD	AVERAGE 1966-1975 *	SAME PERIOD YEAR AGO	PRECEDING PERIOD†	LATEST PERIOD 3rd QTR. 1979
AEROSPACE SALES: TOTAL	Billion $	Annually	26.6	36.6[r]	41.9	43.7
	Billion $	Quarterly	6.4	9.5[r]	11.3	11.4
AEROSPACE SALES: TOTAL	*Billion $*	*Annually*	*27.3*	*23.9[r]*	*25.6*	*26.1*
(In Constant Dollars, 1972 = 100)	*Billion $*	*Quarterly*	*6.9*	*6.2[r]*	*6.9*	*6.8*
AEROSPACE PRIME CONTRACT AWARDS: TOTAL	Billion $	Quarterly	5.8	9.9	13.8	11.5
U.S. Government	Billion $	Quarterly	4.1	5.5	6.9	5.1
Other Customers	Billion $	Quarterly	1.7	4.4	6.9	6.4
BACKLOG (Major Aerospace Mfgrs): TOTAL	Billion $	Quarterly	28.6	51.5	67.7	68.8
U.S. Government	Billion $	Quarterly	15.9	28.6	33.3	33.0
Nongovernment	Billion $	Quarterly	12.7	22.9	34.4	35.8
DEPARTMENT OF DEFENSE						
Aerospace Obligations: TOTAL	Million $	Quarterly	2,712	2,467	3,194	3,737
Aircraft Procurement	Million $	Quarterly	1,986	1,844	2,507	2,985
Missiles Procurement	Million $	Quarterly	726	623	687	752
Aerospace Outlays: TOTAL	Million $	Quarterly	2,405	2,333	2,978	2,928
Aircraft Procurement	Million $	Quarterly	1,741	1,799	2,463	2,346
Missiles Procurement	Million $	Quarterly	664	534	515	582
NASA RESEARCH AND DEVELOPMENT						
Obligations	Million $	Quarterly	780	648	882	903
Expenditures	Million $	Quarterly	789	737	683	874
EXPORTS						
Total (Including Military)	Million $	Quarterly	1,038	2,572[r]	2,741	3,019
New Commercial Transports	Million $	Quarterly	345	658[r]	1,061	1,488
EMPLOYMENT: TOTAL	Thousands	End of Quarter	1,166	992	1,096	1,121
Aircraft	Thousands	End of Quarter	650	546	602	618
Missiles & Space	Thousands	End of Quarter	114	83	98	100
AVERAGE HOURLY EARNINGS, PRODUCTION WORKERS	Dollars	End of Quarter	4.38	7.64	8.11	8.39
PROFITS						
Aerospace — Based on Sales	Percent	Quarterly	2.7	5.1	5.5	5.2
All Manufacturing — Based on Sales	Percent	Quarterly	4.8	5.4	6.1	5.6

* Quarterly average computed as one-fourth of annual average.
[r] Revised.

Source: Aerospace Industries Association

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The Florida Institute of Technology, Melbourne, Florida, and the nearby NASA Kennedy Space Center will be the sites of the 1980 National Aviation/Space Education Convention, sponsored by the American Society for Aerospace Education and the National Council for Aerospace Education.

The convention is expected to bring together more than 1,000 aerospace educators, including representatives of every major national aviation/space education program. Convention '80 will feature an array of leading aviation/space speakers; the latest in aerospace education programs and publications; an extensive exhibit with more than 100 displays; a special program on the Space Shuttle; and the 37th Annual Aerospace Education Awards Banquet.

For additional information, contact the **American Society for Aerospace Education,** 1750 Pennsylvania Avenue NW, Washington, D.C. 20006.

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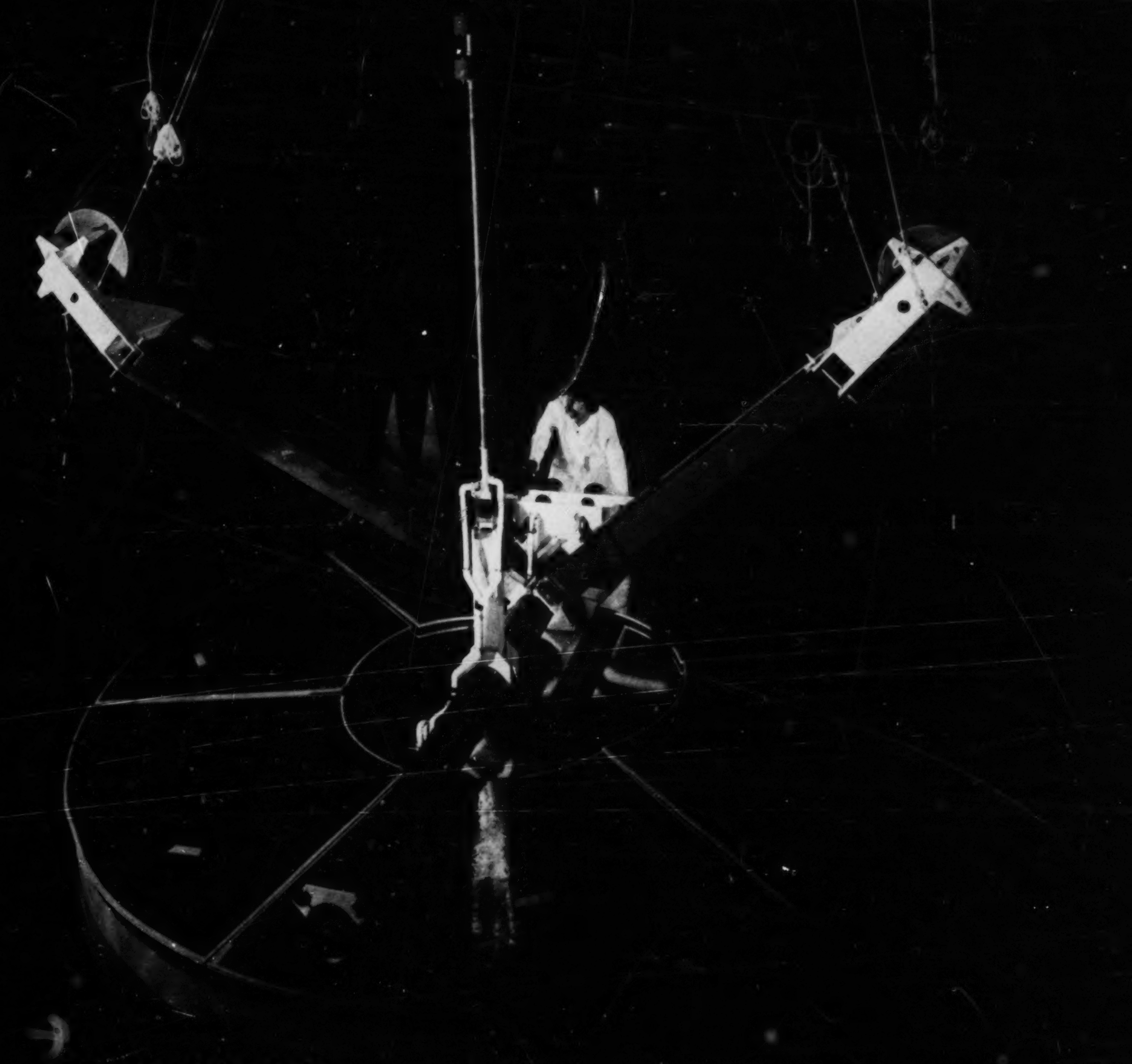

What's Next In AEROSPACE

aerospace perspectives

T. A. Wilson, *Chairman and Chief Executive Officer, The Boeing Company, in an address at the National Research Council Workshop, Woods Hole, Massachusetts:*

"I think the outlook for continued U.S. leadership in transport aircraft is promising if the industry is permitted to operate in a supportive economic and political environment. We need an environment to encourage growth—not misguided policies that strangle it. Unfortunately, in this regard, we've developed a bad habit of shooting outselves in the foot...

"Among the major trading nations of the world, only the U.S. seems to regard foreign trade as a sideline activity which is largely ignored as an economic base for domestic prosperity and jobs, but frequently used to deny sales to some country in an attempt to influence its actions . . . We insist that other nations observe our standards for human rights and environmental regulations if they wish to buy our products—as if the U.S. were the only source for such goods throughout the world . . . U.S. morality has become a major export. Although this sort of pressure seldom has any effect except to eliminate sales—and therefore jobs—for U.S. firms, it continues to be a popular exercise in futility.

"Except for the Export-Import Bank, we have found that most U.S. government activity related to foreign trade has to do with restrictions and prohibitions. In recent months Ex-Im has come under attack—apparently because it has done an excellent job of providing financing to foreign buyers of U.S. products . . .

"We need a long-range policy on foreign trade—one that recognizes the overall benefit of exports for our national economy and American jobs . . . We need to increase, not reduce, our government investment in research and development . . . We should develop a different approach to what is necessary to protect our industries. We need to shuck our national guilt complex about helping industry *before* it gets into trouble...

"Our national must begin to see the big picture, realize the benefits for *all* Americans of saner government/industry relationships, and the absolute necessity for maximum research and development if we are to compete in today's world. The penalty of failure—in terms of the economy, balance of trade and most of all jobs—is so serious that success is not just an objective, it is mandatory."

Harold Brown, *Secretary of Defense, speaking on American nuclear policy to the Naval War College, Newport, Rhode Island:*

"The Soviet leadership appears to contemplate at least the possibility of a relatively prolonged exchange if a war comes, and in some circles, at least, they seem to take seriously the theoretical possibility of victory in such a war. We cannot afford to ignore these views, even if we think differently, as I do. We need to have and we do have a posture—both forces and doctrine—that makes it clear to the Soviets and to the world that any notion of victory in nuclear war is unrealistic.

"Implementing our strategy requires us to make some changes in our operational planning . . . This is not a first strike strategy. We are talking about what we could and, depending on the nature of a Soviet attack, would do in response to a Soviet attack. Nothing in the policy contemplates that nuclear war can be a deliberate instrument of achieving our national security goals, because it cannot be. But we cannot afford the risk that the Soviet Union might entertain the illusion that nuclear war could be an option—or its threat a means of coercion—for them."

Thomas O. Paine, *former Administrator of the National Aeronautics and Space Administration, in testimony on U.S. civil space policy before the Space Science and Applications Subcommittee of the House Science and Technology Committee:*

"Our most recent national space policy pronouncement calls for U.S. leadership, but states that high-challenge initiatives would not be appropriate at this time, and that decisions concerning needed directions for our space programs should be deferred until after the Space Shuttle.

"Ringing rhetoric proclaiming U.S. leadership in space is no substitute for plans and programs. In my view, it is self-delusive to give lip service to leadership while avoiding initiative and commitment. America faces a clear choice today: should we invigorate our space program or continue to drift downward?"

Joseph R. Carter, *Chairman and Chief Executive, Wyman-Gordon Company, addressing a company stockholders meeting:*

"A subject which is a major concern of mine is the almost complete dependency the United States has on foreign countries for many of our critical materials. We must import more than 50 percent of our needs for 18 of the minerals considered essential to the United States economy and security...

"That we need a National Materials Policy is beyond dispute. Further than that, we need a National Plan for Action. Enough studies have been made, enough committees and commissions have examined the issue and heard testimony. It's time to remove politics and bureaucratic inertia from our materials dilemma before it becomes as confusing as our National Energy policy. The subject, in my opinion, has been dealt with all too lightly by both industry and government. The needs and shortages are here. It is a subject which should be addressed at the highest levels of industry and government if we are to avoid some very serious consequences in the next decade."

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COVER
At Hughes Aircraft Company, the new Leasat communications satellite undergoes antenna checkout. The Leasat system will provide defense communications coverage around the world from four orbital positions above the United States and the Atlantic, Pacific and Indian Oceans.

The purpose of AEROSPACE is to:

Foster understanding of the aerospace industry's role in insuring our national security through design, development and production of advanced weapon systems;

Foster understanding of the aerospace industry's responsibilities in the space exploration program;

Foster understanding of civil aviation as a prime factor in domestic and international travel and trade;

Foster understanding of the aerospace industry's capabilities to apply its techniques of systems analysis and management to solve local and national problems in social and economic fields.

AEROSPACE is published by the Aerospace Industries Association of America, Inc., the national trade association of the designers, developers and manufacturers of aircraft, missiles, spacecraft, their propulsion, navigation and guidance systems and other aeronautical systems and their components.

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EXPORTS AND PRODUCTIVITY

By KARL G. HARR, JR.
President,
Aerospace Industries Association

Last year, the United States recorded a trade balance deficit of more than $27 billion. It marked the seventh deficit year of the past decade and the third consecutive year in which the deficit topped $25 billion. These trade deficits are severely impacting the U.S. economy, reducing the value of the dollar abroad and contributing to inflation at home.

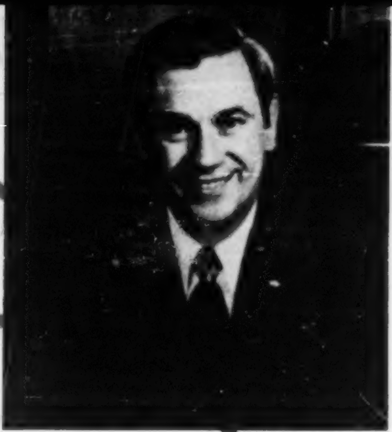
We tend to think that the problem centers on our massive oil imports. That, to be sure, is a big part of the problem—but by no means the extent of it. Oil imports can be offset by rising levels of American exports, and aerospace exports are making a major contribution in that regard. In many other trade areas, however, our exports are declining rather than increasing; the overall American share of free world exports dropped sharply in the decade of the seventies.

There are a number of reasons for our trade decline, principal among them government-imposed disincentives that retard export growth and hamper industrial productivity. If we are to restore our export posture to the levels of earlier days, and thereby benefit the national economy, we must address these matters—and soon.

This issue of *Aerospace* focuses on the interrelated subjects of exports and productivity—and what we may do to improve them. We are fortunate to have as contributors two of the best qualified people in the world: Ambassador Reubin O'D. Askew, President Carter's principal advisor on international trade, and Thomas J. Murrin, president of Westinghouse Public Systems Company, one of the nation's foremost industrial leaders who has devoted particular effort to the study of productivity. They write bluntly, forcefully and explicitly on what the United States must do to effect a turnaround in our export/productivity situations. We think their comments are *must* reading.

EXPORTS: Economic Cornerstone

By Ambassador Reubin O'D. Askew
United States Trade Representative



As United States Trade Representative, a post which carries ambassadorial and cabinet rank, Reubin O'Donovan Askew is President Carter's principal advisor and the nation's spokesman on matters relating to international trade. A native of Florida, he has served in a number of public offices in that state, including two terms as governor (1970-79). He assumed his duties as Trade Representative in October 1979.

In the days immediately following World War II, the United States was, without question, the preeminent economic power in the world. We dominated the world economy, in part because of our own vast resources, but principally because much of the rest of the world had been devastated by a global war from which we had emerged relatively untouched.

There seemed little that the United States could not accomplish in those days. It seemed inconceivable that other nations might be able to compete with us for foreign markets, much less for markets within the United States.

In retrospect, we can see that those were unnatural conditions in unnatural times. Our own enlightened efforts to help rebuild the economies of Europe and Japan as bulwarks against communism ensured that America's economic might would not go unchallenged for long. Yet we assumed, incorrectly, the inevitability of American economic superiority. And many of our industries neglected the cultivation of foreign markets, believing, unwisely, that they did not really need them. Now they know better.

The day has long since passed when the United States could sustain, without effort and without the exercise of ingenuity, a dominant position in the world trading community. Neither economically nor otherwise is an American advantage in the world marketplace preordained.

It is time we recognized this fact, accepted the changing world for what it has become, and what it is becoming, and translated this recognition and this acceptance into a new national approach to world trade.

We must change with the changing world. We must exploit our own still extensive comparative advantages as a trading nation. And we must do so aggressively in the entrepreneurial spirit that has long characterized American commerce.

Trade is of vital and increasing importance to the United States. Trade constituted just four percent of our Gross National Product in 1969. It accounts for more than twice that now. American imports and exports were valued at $35 billion annually in 1960. They are valued at nearly $270 billion annually today.

Figures in the aerospace industry are comparable. In 1960, the aerospace trade of the United States was valued at $1.8 billion, with aerospace exports representing eight percent of manufacture exports. Today, the dollar value of aerospace trade is eight times what it was in 1960, and aerospace exports represent 10 percent of all U.S. exports of manufactures. Aerospace sales are a major source of surplus to offset the deficit in our overall balance of trade.

One of my major objectives as United States Trade Representative is to assure that governmental policy takes full account of the increasing impact of trade on the American economy and the increasing reliance of Americans on trade for their livelihood. A firm devotion to trade must be a cornerstone of our economic policy in the United States.

In particular, we must find more and better markets for the export of American goods and services, even as we seek to secure and improve our markets here at home. And we must work to support the export efforts of our leading export industries. Aerospace is, of course, a préeminent example, employing as it does more than one million Americans in work for which we still have a comparative advantage.

Exports are essential to the American economy. They account for one out of every eight U.S. manufacturing jobs, the production of one out of every three acres of American farm land, and, along with the international activities of American firms, almost one dollar out of every three dollars of U.S. corporate profits. About one-sixth of all we grow or make in America today is sold abroad.

Exports are even more important to the aerospace industry. Last year, exports accounted for 61 percent of commercial transport sales, 53 percent of civil helicopter sales, and 27 percent of general aviation aircraft sales.

The United States is losing too often in the constant competition for trade among nations. The American share of overall free world exports declined from 15.4 percent in 1970 to 12.2 percent in 1978. At the same time, the percentage share of most of our trading partners in the European community remained virtually unchanged, while that of Japan increased markedly. In brief, as world trade has become more important to America, America has become less important in world trade.

Unfortunately, this is true of aerospace, as it is for other American industries. Our aerospace industry remains, by far, the leader in the world. But 10 years ago we received 95 percent of free world orders for commercial jet aircraft. Last year, we received only 70 percent of those orders. This trend must change.

Given our size, our skills, our resources, and our tradition of enterprise as a nation, it is plain that our relative decline as a trading nation is totally unnecessary. We must begin now to increase our share of world trade. We must make America a more active and more forceful presence in the world trading community. We must demonstrate anew the ability of the United States to be a reliable supplier of quality products.

If we are to reap the benefits of trade, however, American business must be free to compete on more even terms in the marketplace. To this end, I am persuaded that we must constantly review all governmental actions and policies which take the form of export disincentives.

Our trading partners have incentives and governmental export promotion programs of infinite variety. In contrast, we often have created impediments and barriers which even our most competitive exporters must surmount before they can begin to compete in the international arena.

We have not done enough to remove these barriers or to assist in creating structures with which we may compete as effectively as our trading partners do in the world marketplace. In many instances, we have tied our own hands needlessly. Perhaps the biggest incentive government could provide for increasing exports would be to reduce the number of export disincentives which government imposes.

Any list of export disincentives we might write would be quite long. And I am not unmindful that many of these disincentives are important instruments of American foreign or domestic policy. Some may even be described as essential. But not all these disincentives are needed—not by any means. We are committed in the Carter Administration to removing needless disincentives as one means of fulfilling the President's commitment to a new export policy.

First, I believe, as many others do, that some changes are needed in those provisions of our tax code which

Incentives for Exports, Selected Countries
Tax Incentives for Exports

	Belgium	France	Germany	Italy	Luxembourg	Netherlands	United Kingdom	Ireland	Denmark	Norway	Sweden	Switzerland	Austria	Portugal	Australia	New Zealand	Japan	Canada	United States
Partial or total exemption on foreign branch income	•	•	•		•				•	•				•	•				
Foreign subsidiaries not subject to tax	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•		
Foreign branch losses deductible	•		•	•		•	•	•	•		•				•		•	•	•
Partial or total exemption on foreign source dividends	•	•			•	•			•			•	•	•	•	•		•	
Special deferrals of domestic income		•	•							•							•		•
Export tax incentives		•				•	•	•		•	•		•		•	•	•		DISC*
Non-enforcement of inter-company pricing rules	•	•				•	•				•								
Border tax adjustments	•	•	•	•	•	•	•	•	•	•									

* Domestic International Sales Corporation only

Source: Statement of the Special Committee for U.S. Exports in U.S. House of Representatives

This table underlines the fact that foreign competitors receive a number of tax incentives not available to their U.S. counterparts, hence enjoy a competitive edge. A similar situation exists in non-tax incentives.

tax Americans living and working abroad. The current laws, and the regulations implementing them, tend to discourage American companies from pursuing business abroad and, furthermore, from hiring Americans to conduct business abroad when they do choose to pursue it.

I believe also that some clarifications are desirable in the Foreign Corrupt Practices Act of 1977. I would not for a moment suggest that we should in any way condone bribery of foreign officials by American businessmen. But this law as now written is so vague and so ambiguous that American businessmen simply cannot be certain of what it means or what it compels them to do. Fearful of this law and its stiff penalties, they hesitate even to engage in foreign trade. We must clarify this law so that it will be effective, so that it will survive the test of judicial scrutiny, and so that it will not needlessly inhibit trade.

In the area of export controls, we need to shift the burden of the debate. We need to look carefully at export license denials, whether for reasons of national security or foreign policy. In evaluating an export license request, the burden of proof should be on those who would deny the export, not on those who would permit it. Recognizing that the United States is not always the sole source of particular products, we must seek to avoid situations in which U.S. export license denials serve principally to assure market opportunities for foreign competitors.

Another area in which we must continue to take a very strong stand is that of official export credits. For several years, we have been urging our trading partners to raise the general level of interest rates on official export credits—so that they will bear a closer relationship to market rates. The Europeans have recently offered to increase the general interest levels by 0.25 percent for loans to relatively poor countries and by 0.75 percent for loans to relatively rich and intermediate countries. Simply put, this offer is an inadequate reflection of changes in interest rates over the past two years—not only here, but in Britain, France, Japan, and elsewhere.

We can raise our export credit interest rates unilaterally—and thus lose exports as a result of non-competitive financing. Alternatively, we can match the excessively low export credit rates of our competitors, and continue to do so until such low rates cease to be a factor in purchasing decisions. Once that happened, our competitors probably would agree to move jointly to higher and more reasonable levels. Thus, we have no choice. We must be competitive in export credit financing and make our competitors realize the futility of subsidizing interest rates.

We must, of course, continue to fulfill our obligations as a responsible member of the world trading community. We must abide by our international commitments and live up to the international ideals of trade to which this nation has long subscribed.

But too often we have been content as a nation simply to abide by our international commitments. Too often we have focused more on our commitments than on our rights. Too often we have been willing to sacrifice the commercial interests of the United States for the sake of a political harmony with other nations which proves illusory.

Our trading partners have never hesitated to assert their rights in the international trading community. Our competitors have never hesitated to promote their trade interests —and rightly so. We should not expect them to be anything less than active proponents of their own legitimate national interests.

'Growing government regulation and the expansion of government controls is imposing a heavy cost on society, reducing the rate of productivity growth, and reducing technological innovation. In the last 10 years, environmental, health and safety regulations have cut about 1.4 percentage points per year from productivity growth.'

But they should expect nothing less from us. We too must assert our economic interests. We too must be tough negotiators. We too must drive hard bargains. And we must work constantly to create additional opportunities for American commerce.

Whatever else we do, we must address the real root cause of much of our national distress—which is the gradual but unmistakable erosion of America's vital industrial base. A strong industrial base is essential to the revitalization of the American economy—and especially to the creation of new jobs. Without a solid economic base—one capable of producing quality manufactured goods at a competitive price—we will have little hope of sustained growth or of continued improvement in our standard of living.

Some have advocated the adoption of various sectoral policies to attend to the needs of particular industries which have been affected by our economic decline. What we need, however, is not a sector-by-sector government bail-out, which would only add to our difficulties, but rather a national policy for all our industries, agricultural as well as industrial. This policy should be national in scope, taking into consideration the changing structure and the changing needs of our economy. And it should also be international, taking into account our vital needs to export, to import, and to compete as freely and as fairly as possible in our increasingly intertwined world.

We need a policy by design and not by indirection. This policy will not be easy to implement, but it is needed nonetheless.

We must use government as a catalyst to revive the entrepreneurial spirit in American life and reconstruct our economic capacity as a nation.

We must work together in partnership—government, business, and labor alike—to build on our strengths in America, and not subsidize our inefficiencies.

We must not discourage, through governmental policies, the development of those industries which are most likely to be able to compete. Rather, through carefully crafted tax incentives, and through increased government funds for needed research and development, we must ensure that our most competitive industries are able to compete as they should.

We must eliminate needless laws and regulations which stem the creative flow of free enterprise, even as we encourage business to renew its faith in free enterprise as well.

We must encourage risk-taking where taking risks is in the national commercial interest.

We must work to improve our efficiency, our productivity, our technology, and our quality control.

We must allow accelerated depreciation on plants and equipment as a necessary spur to modernizing our antiquated industries. And we must develop additional policies as well to encourage savings and enterprise. All this is essential to an effective national industrial policy.

I am encouraged by the fact that, increasingly, opinionmakers, and decisionmakers, both within government and without, are recognizing the need for such a planned policy. And I am confident that, in giving this matter the serious attention it deserves, we can forge our collective wisdom into the effective, integrated, overall policy our nation needs to prepare for the challenges of the coming decade and the coming century.

PRODUCTIVITY: The Competitive Threat

By T.J. Murrin, *President*
Public Systems Company
Westinghouse Electric Corporation

As president of Westinghouse Public Systems Company, T. J. Murrin is responsible for the operations of four major Westinghouse groups engaged in a broad range of worldwide activities, including production of aerospace and defense electronic systems and a variety of non-aerospace equipment. Mr. Murrin graduated from Fordham University in 1951 and has been with Westinghouse ever since. He is a member of the Westinghouse Management Committee, the corporation's top policy and decision-making body; he is also a member of the Board of Governors of Aerospace Industries Association and the Advisory Board of the Center for Strategic and International Studies.

I am concerned about our individual companies' and our nation's need to stimulate productivity improvement. I am also concerned about our nation's export policies—or the lack of them.

I have two reasons for these concerns. First, unless we do stimulate productivity growth, our nation will continue to experience inflation that could continue in the double digits. My second concern is more fundamental. Our very ability to compete with manufacturers from abroad is at stake; the lack of productivity growth is making us less competitive in export markets around the world. Our continuing large trade deficits clearly highlight the seriousness of the problem.

During the past 10 years we were introduced to rampant inflation, recession, OPEC and the oil embargo, a decline in the economic and foreign policy influence of the United States of America, and a massive conventional and nuclear arms build-up by the Soviet Union.

I believe that, as a nation, we are waking up and getting ready to do something about the problems of the Seventies. Among the challenges we must meet are inflation, the stimulation of productivity improvement, and international competition which is severely affecting our balance of trade and jobs here at home. These matters are all very much interlinked, since if we can significantly stimulate productivity improvement we can begin to solve the other two problems.

Knowledgeable economists predict that unless we have greatly improved productivity growth, the nation can expect a continuing eight-to-nine percent inflation rate. And if productivity levels decline, as they did last year inflation levels will be even higher. So it is essential that we begin the task of substantially improving productivity. Given our current situation of "stagflation" and productivity decline, a number of economists are saying that a one percentage point improvement in productivity can reduce the inflation rate by two percent to three percent over a multi-year period.

Just as worrisome as the inflation problem is the challenge of growing international competition and rapidly improving productivity abroad. For example, Japan and West Germany are projected to soon overtake the U.S. in production per employee—and our once dominant position in the industrial world will be gone.

When we combine that frightful prospect with the military buildup of the Soviet Union, it becomes clear that the preeminence of the U.S. in general—and of U.S. industry in particular—is deteriorating in a worrisome way.

We have witnessed major competitive changes overseas. Competitors who could previously survive only in their protected home markets now effectively compete with us around the world and in our home U.S. market.

Take, for example, Japan. Over the last 20 years they have challenged our American preeminence in several industries—earlier in steel making, shipbuilding, motorcycles, home electronics, and automobiles, now in micro-electronics; computers, communications, and, soon perhaps, even in aerospace and defense.

Westinghouse Electric Corporation has recently been studying in depth what it is that the Japanese do to be so successful at productivity improvement. One of our recent study teams visiting Japan was composed of personnel and labor experts and another was made up of production specialists. Both reported that the Japanese are already well ahead of us in a number of significant areas related to production technology and human resources. The teams also reported that the Japanese have developed such immense momentum that their productivity improvements should continue well into the future.

So it is becoming very clear that we as a nation—and we as manufacturers—face some very crucial competitive threats. We have to awaken ourselves, our employees, union leaders, government leaders, academic associates and the general populace to these new realities.

Last year our nation's productivity actually declined by about one percent, and the year before it rose only one-half percent. During the last decade, productivity improvement in the U.S. has averaged 2.3 percent per year, while it was rising more than twice as fast in most of Europe and three to four times as fast in Japan.

'The nations with the best record of productivity improvement are those nations which develop a consensus between industry, government, labor, and academe, with these key elements of society working synergistically to achieve common goals. Unfortunately, in this country, we often have an adversary relationship . . . which prevents us from "getting our act together" to improve productivity while achieving societal goals.'

When one looks at export figures, you see that the U.S. share of the world exports has consistently been declining—from 40 percent in 1950 to about 13 percent today. And apparently, West Germany could soon overtake the U.S. as the world's leading exporter.

Part of the reason behind these ominous prospects is our nation's decline in capital investment per worker and in the proportion of Gross National Product devoted to research and development. While our level of R&D effort has declined, it has risen in Japan, West Germany, and in the Soviet Union.

MANUFACTURING PRODUCTIVITY 1967-77

Year	United States	France	West Germany	Japan	United Kingdom	Canada
1967	100.0	100.0	100.0	100.0	100.0	100.0
1968	103.7	111.4	106.9	112.6	107.1	106.8
1969	104.8	115.4	113.4	130.0	108.4	113.1
1970	104.4	121.2	116.1	146.5	108.6	114.7
1971	110.1	127.6	121.4	151.0	112.9	122.9
1972	115.7	135.1	128.7	162.3	121.2	128.5
1973	118.8	142.5	136.6	181.2	126.2	134.3
1974	112.6	146.5	145.0	181.7	127.6	136.6
1975	118.2	150.3	150.4	174.6	124.2	133.3
1976	123.2	164.0	162.8	188.7	128.4	139.4
1977	126.1	172.6	169.6	199.2	126.3	146.1

Source: Department of Labor, Bureau of Labor Statistics.

This table shows the relative changes in productivity among the manufacturing industries of six major nations over an 11-year span, starting with a base year 1967. While the U.S. and the United Kingdom experienced moderate productivity gains, they were far outpaced by other nations, particularly Japan.

In the 1980s we face the prospect of our manufacturing and product technologies no longer being preeminent in the world, and our level of productivity may no longer be the highest. Stimulating manufacturing technology and capital investment in modern production facilities—and, of course, stimulating productivity growth—will be essential to our very ability to compete during the eighties and nineties. It is also essential to improving the quality of life in general, and particularly the quality of our employees' work lives.

Protectionist action clearly will not solve the competitive problem; it will only amount to "burying our head in the sand." Clearly, we need to address these competitive threats squarely.

What does it take to stimulate productivity growth? It takes a concerted effort in at least four basic areas.

- One, we need to stimulate innovation in both product-oriented technologies and in manufacturing technologies.
- Two, we need to stimulate capital investment in new facilities and in the replacement of technologically-obsolescent equipment with new productivity-improving equipment in both white collar and blue collar areas.
- Three, we need to greatly improve our relations with government and reduce regulatory and other government barriers to productivity growth.
- Lastly, but most importantly, we must manage our people and businesses better than we have ever done before.

That's a tall order, but one that we must absolutely address.

Technological innovation—which gives us better ways of doing something—has tremendous potential for improving productivity. Over the last 50 years, at least 40 percent of our nation's productivity growth has come from technology innovation.

Several nations, such as Japan, have strong national programs directed at improving manufacturing technology. Except for the U.S. Air Force manufacturing technology program and the Department of Defense very-high-speed integrated circuit program, we have no similar effort in this country. Even eastern European countries have national programs for manufacturing technology.

Perhaps by using the Air Force manufacturing technology program as a basic building block, we can evolve a major national effort directed at manufacturing technology. This should, for example, include application of robots to manufacturing jobs that people no longer want to do—the hot, hazardous, heavy and monotonous types of work.

Government can help by making changes in the federal tax structure to help stimulate R&D and venture capital formation; by increasing direct and indirect investment in R&D; and by fostering a climate which encourages innovation. Too often, government bureaucracy and regulation have the effect of dampening innovation, since the process of getting a new technology applied is too cumbersome and too risky.

Changes which should be made in the tax structure include an investment tax credit for R&D to encourage a much greater private R&D effort, and accelerated depreciation of plant and equipment to encourage quicker replacement of equipment with new, productivity-improving technologies. A reduction in the capital gains tax rate would help encourage investment in risk ventures.

To encourage saving and investing by individuals, the taxation of phantom capital gains and savings interest resulting solely from general price inflation should be eliminated. The double taxation of corporate income distributed as dividends should be stopped. And the basic corporate income tax rate should be lowered to compensate for the impact of inflation on real earnings which should be used for capital investment.

Growing government regulation and the expansion of government controls is imposing a heavy cost on society, reducing the rate of productivity growth, and reducing technological innovation. In the last 10 years, environmental, health and safety regulations have cut about 1.4 percentage points per year from productivity growth. We have been paying for these sometimes worthwhile goals by diverting funds and effort that should be directed to productivity improvement.

The nations with the best record of productivity improvement are those nations which develop a consensus between industry, government, labor, and academe, with these key elements of society working synergistically to achieve common goals.

Unfortunately, in this country, we often have an adversary relationship—particularly between government and business—which prevents us from "getting our act together" to improve productivity while achieving societal goals. Therefore, we must work effectively to reverse this situation and to achieve a more productive partnership.

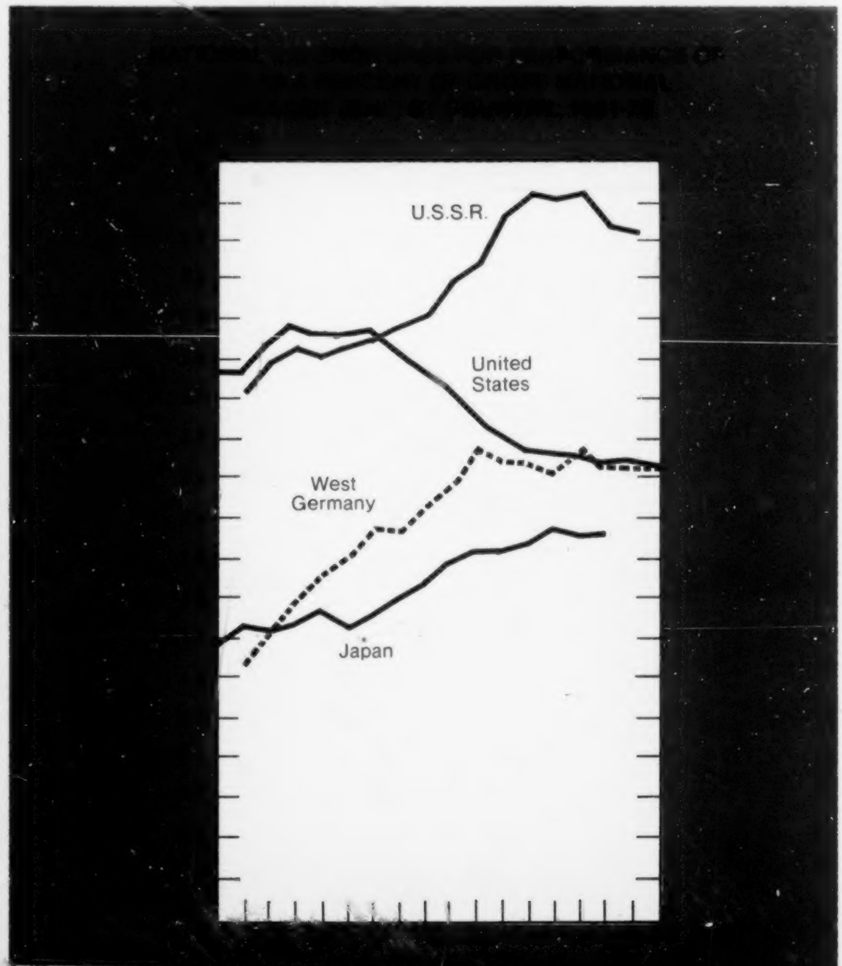
Improving the way we manage our people and resources has great potential for productivity improvement. Recently, a Gallup Poll indicated that half the wage earners surveyed said they could accomplish more each day if they tried and three out of five said they could improve output by better than 20 percent. We have found the results of our internal Employee Attitude Surveys to be very consistent with such Gallup Poll results.

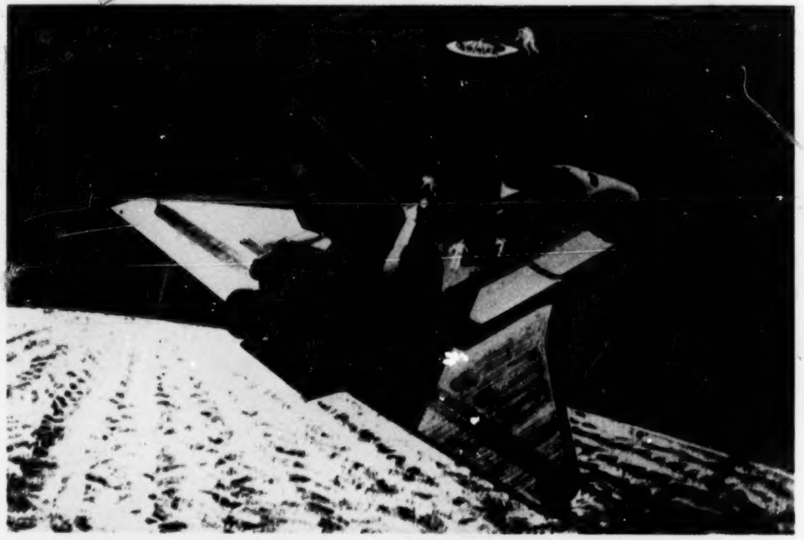
In the past we could ignore many of the export advantages enjoyed by our foreign competitors because we were the most productive country in the world, with clearly superior technology. But in the 1980s that will no longer be true, and as our comparative advantages shrink, these structural and incentive differences, together with differences in the government-industry relationship, will clearly make us non-competitive in many areas.

Many government regulations seem to assume that the U.S. has a monopoly position in world trade and that we have the right to impose our morals on the rest of the world. Both of these assumptions are flawed. Instead of being a beacon of morality guiding the saved from a corrupt world, we are instead engaged in self-flagellation that much of the world views with amusement.

An export competitiveness study conducted by the Center for Strategic and International Studies concludes that the U.S. is still operating under the premises of the Marshall Plan regarding our industrial export posture. The report states that a total reevaluation of our industrial export and competitiveness posture should have been undertaken in the early 1960s and followed then by major changes. The judgment that we are 20 years late in changing our nation's industrial export policies makes it absolutely essential that we make such a posture change a high-priority action item for our nation.

If we retain our current export monopoly mentality coupled with the Marshall Plan mentality we may well end up with a much-reduced economic stature. That is unacceptable. We must make productivity improvement a way of life for our companies and our nation, so that we can stay ahead in the crucial competitive races of the 1980s.





What's Next in AEROSPACE

The largest industrial exhibition of aerospace technology ever displayed in the United States was the feature attraction of the American Institute of Aeronautics and Astronautics' 1980 annual meeting, held in early summer at Baltimore's spacious new Convention Center. Global Technology 2000, as the technical display was called, provided a preview of what's next in aerospace—the products and processes now in development for service use by the end of the century, along with long range concepts for the next century. More than 40 U.S. and foreign companies sponsored exhibits in four major areas of aerospace activity: transportation, energy, space science and applications, and defense systems. The broad technological panorama presented by GT 2000 is exemplified on the following pages by a representative sampling of the exhibits shown by major U.S. manufacturers.

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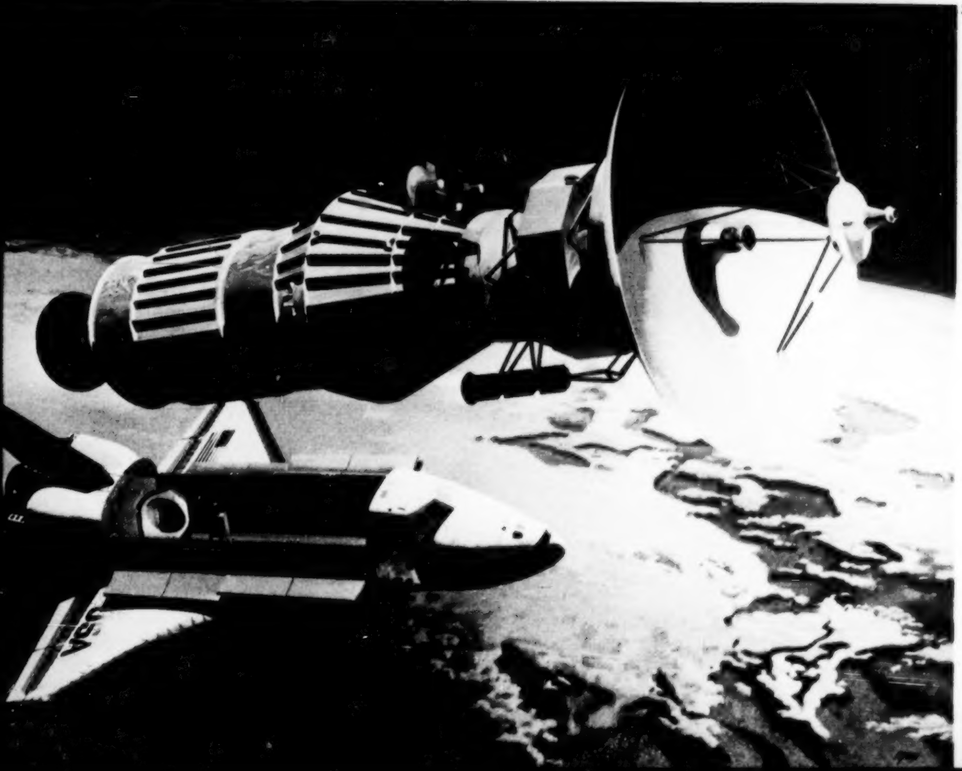

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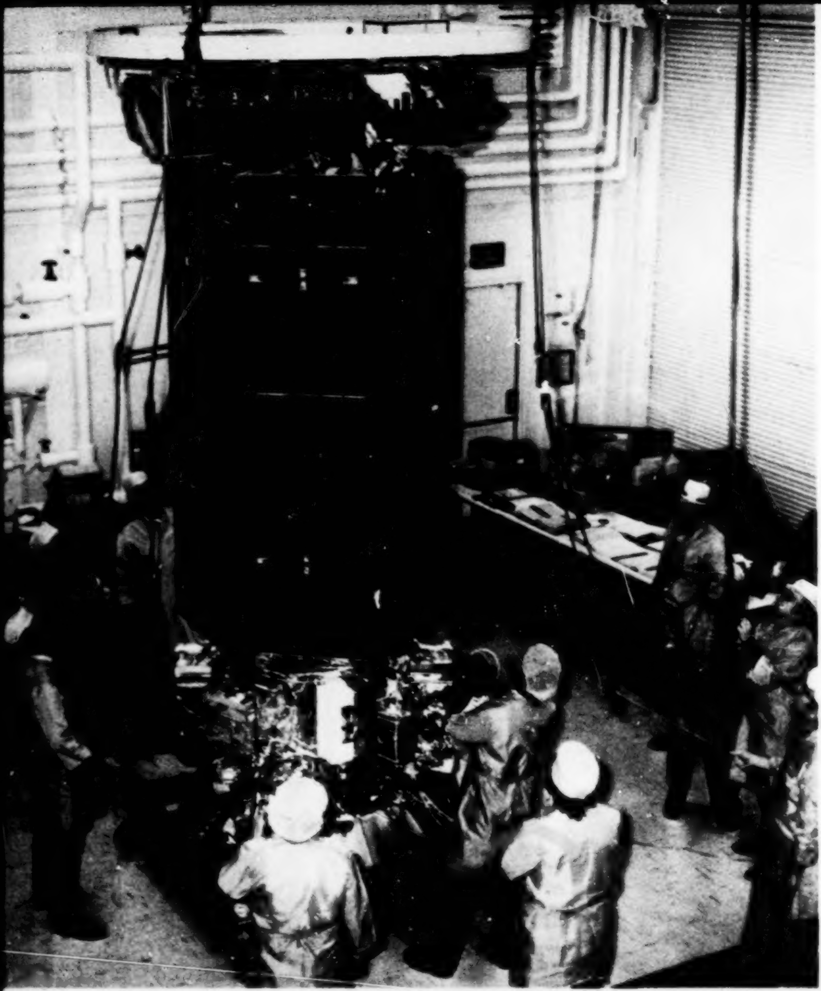
1. One of the most scientifically exciting space projects of the 1980s is NASA's Space Telescope, to be Shuttle-launched in 1984. The 12-ton system will be able to see celestial objects 50 to 100 times fainter and seven times more distant than can be seen by the largest Earth-based telescopes, hence it will expand the observable portion of the universe 350 times. Lockheed Missiles & Space Company is NASA's prime contractor for systems engineering and the Support Systems Module, which accurately points the telescope and returns images to Earth; Perkin-Elmer Corporation is prime contractor for the Optical Telescope Assembly.

2. With the Manned Maneuvering Unit (MMU), astronauts will be able to move about in orbit to perform such tasks as satellite servicing, repair or retrieval, inspection of the Shuttle Orbiter, rescue operations, scientific investigations and in-space construction work. The backpack unit includes propulsion thrusters, directional controls and life support equipment for as much as six hours. Martin Marietta Aerospace is developing the MMU under contract to NASA's Johnson Space Center.

3. For space payloads that must be boosted into interplanetary trajectories or Earth-orbital paths higher than the Shuttle Orbiter's 500-mile operational altitude, NASA and the Department of Defense will employ "upper stage" space tugs. The one pictured is the Inertial Upper Stage (IUS), shown in this artist's conception mated to NASA's Galileo spacecraft, which will conduct an advanced reconnaissance of Jupiter. The solid-fuel IUS is being developed by Boeing Aerospace Company under contract with the Air Force Space and Missile Systems Organization; it will be used to boost both DoD and NASA payloads.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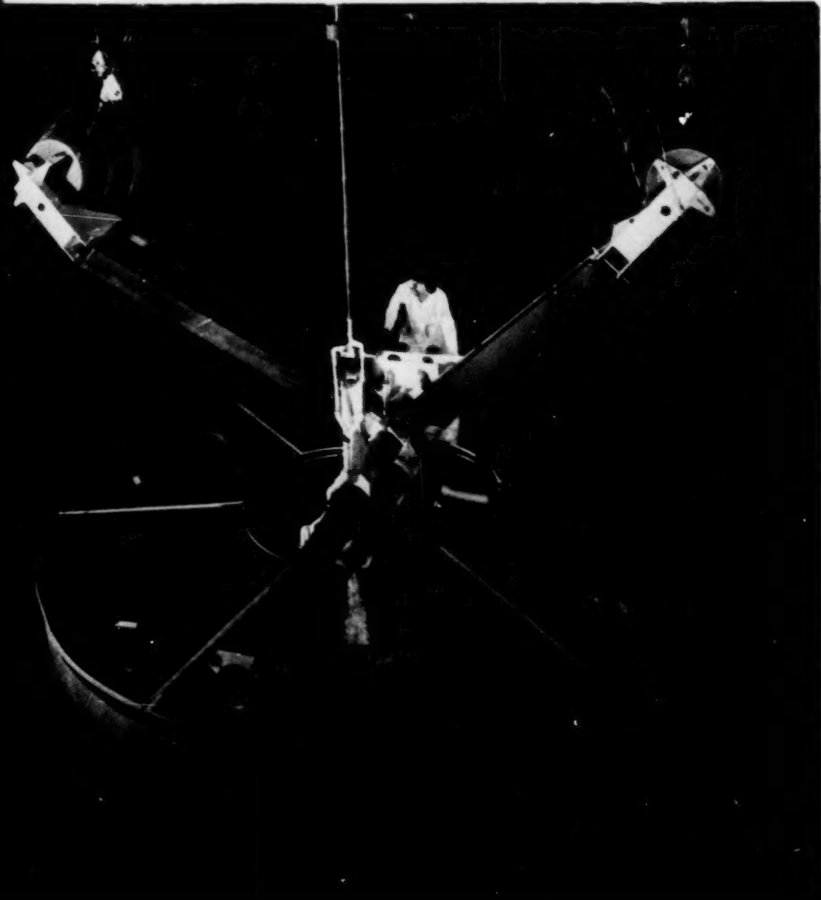
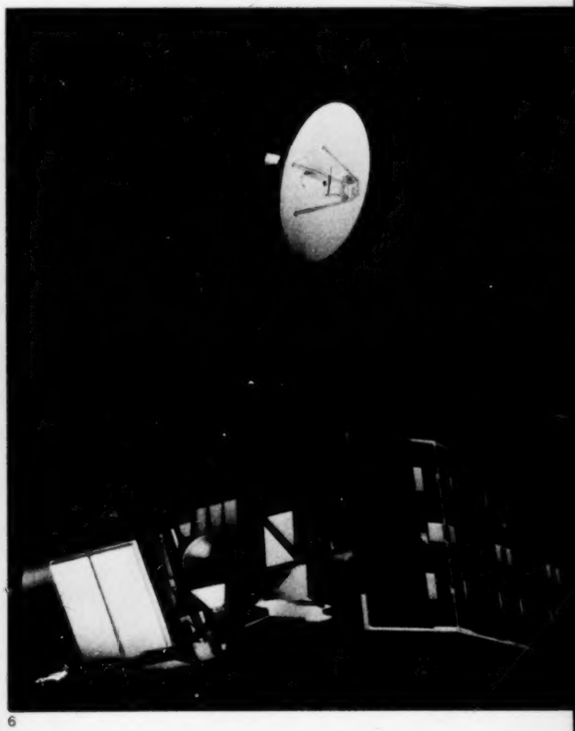
4. Soon to be launched, the NOAA-C pictured is the third of eight satellites in an advanced series—operated by the National Oceanic and Atmospheric Administration—which will provide the most comprehensive meteorological and environmental information ever relayed from space. In addition to weather forecasting, NOAA-C will send data applicable to hurricane warning, solar research and radiation warning, and a variety of useful applications in the agriculture, commercial fishing, forestry, maritime and other industries. Later satellites in the series will have equipment for search and rescue missions. The NOAA satellites are produced by RCA Astro-Electronics, a unit of the company's Government Systems Division.

5. In the photo, the antenna system of Hughes Aircraft Company's Leasat communications satellite is undergoing a test. Leasat represents a new telecommunications concept wherein Hughes will build, launch and operate a complete multi-spacecraft comsat system and lease worldwide communications services to large-scale users. First user—beginning in 1982—will be the Department of Defense; Leasat will relay signals to mobile and fixed air, surface and subsurface stations. Hughes Space and Communications Group is building the satellites and Hughes Communication Services, Inc., a subsidiary, will operate the system.

6. NASA's Landsat remote sensing satellites acquire voluminous data about Earth surface features from orbital altitudes. Landsat data has been used in about 80 different applications, including agricultural inventory, oil/mineral prospecting, land classification, pollution monitoring, improved mapping, delineating urban growth patterns, and studying floods to lessen their devastation. The spacecraft pictured, built by General Electric Company's Space Division, is Landsat D, fourth and most advanced of the series; it is scheduled for orbital duty beginning in 1982.

5

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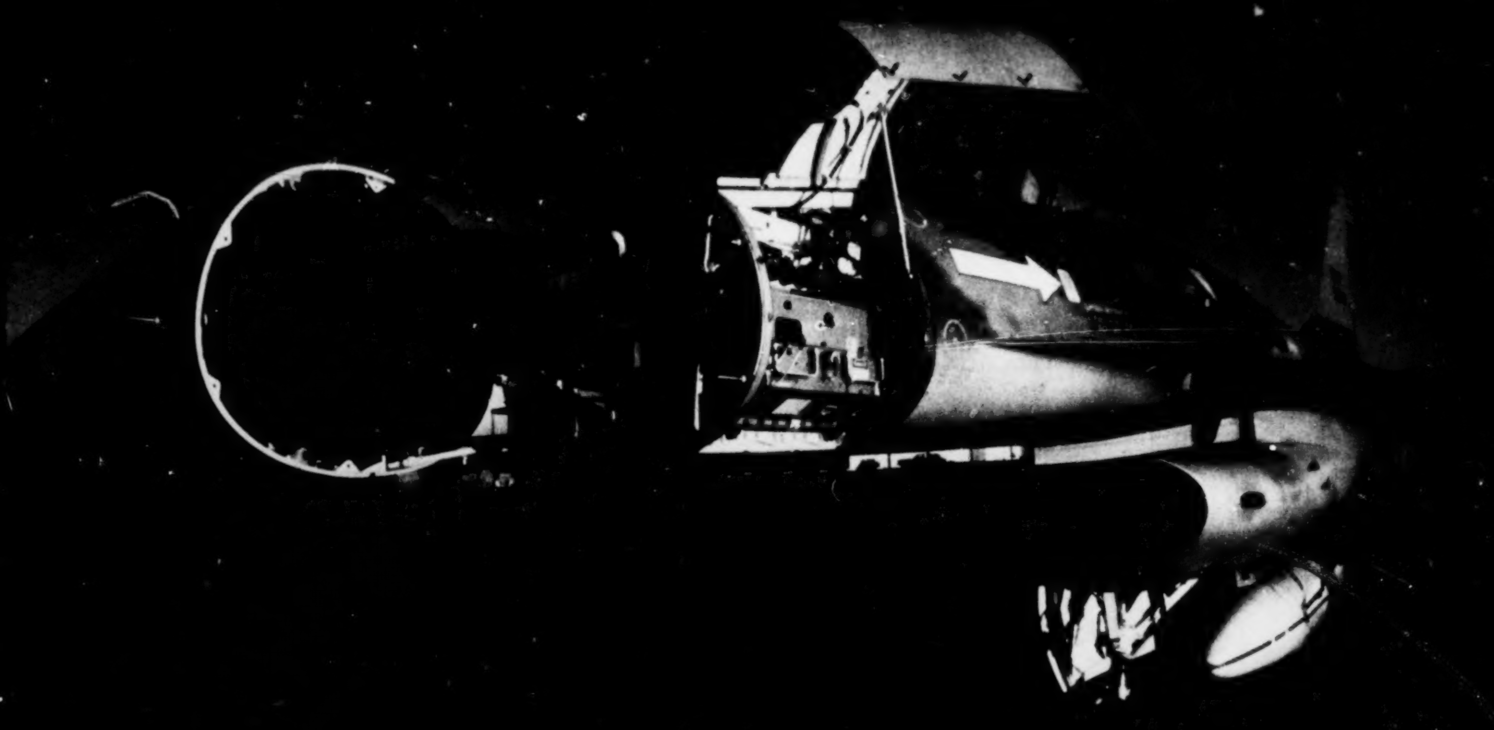

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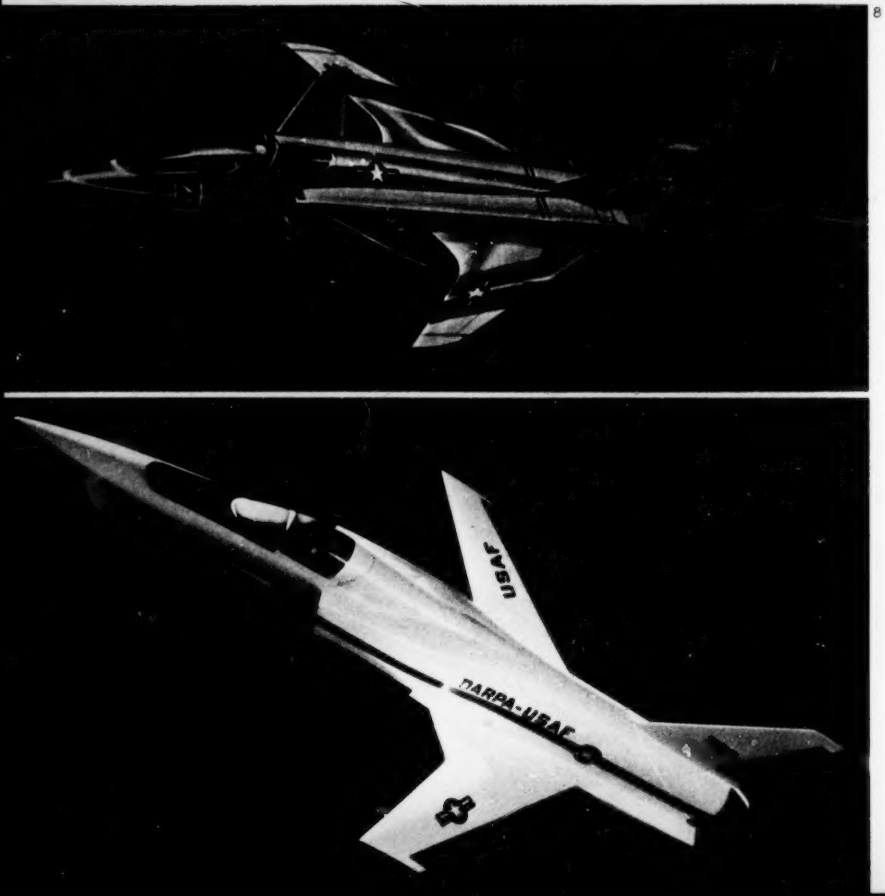
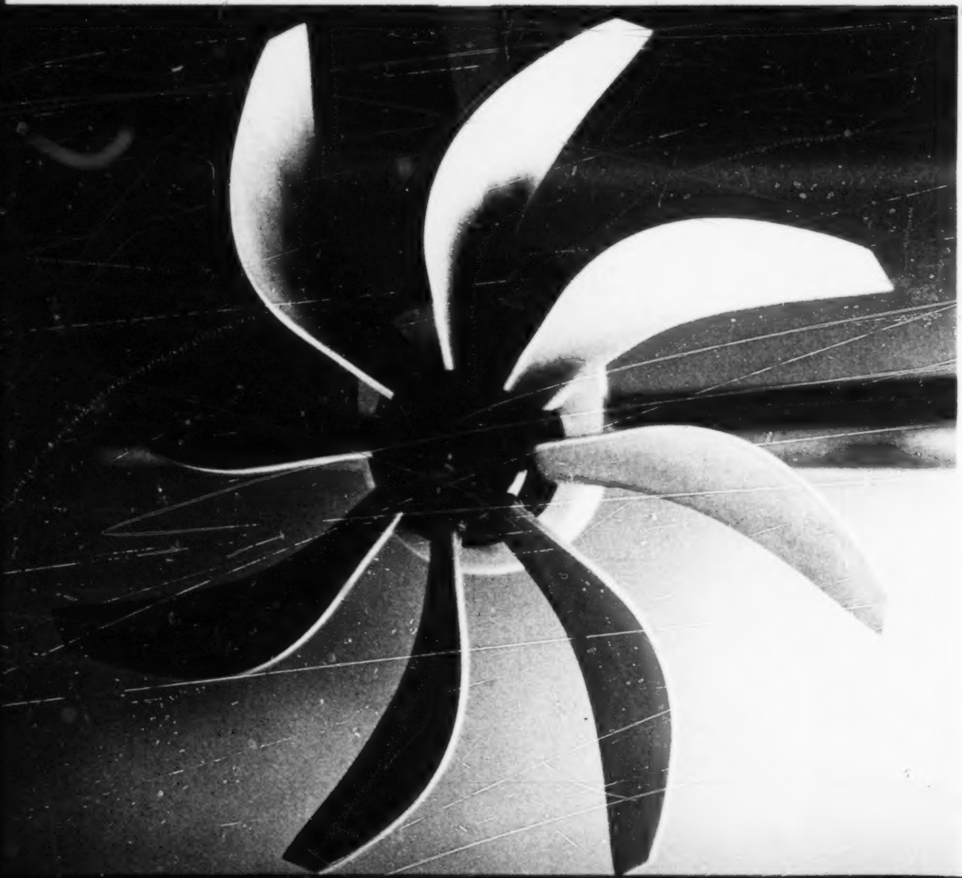


7. The APG-66 all-weather fire control radar for the USAF/General Dynamics F-16 fighter exemplifies a family of military airborne electronic systems produced by Westinghouse Electric Corporation's Defense and Electronics Systems Center. The APG-66 offers 10 radar modes to support a variety of F-16 missions, such as air combat, ground attack and sea lane defense. To free the pilot for maneuvering to make best use of his weapons, a digital computer commands all radar functions, selects the operating mode, calculates and routes data to the fire control system. Additionally, the radar tests its own operation and advises pilots or ground maintenance personnel of malfunctions.

8. An old concept first studied 40 years ago—sweeping aircraft wings forward—offers opportunity for major breakthroughs. Made possible by advances in composite material technology, aircraft with fore-swept composite wings could be lighter, smaller and less costly than equivalent performance planes with aft-swept metal wings. The forward sweep concept is the subject of extensive investigation by the Defense Advanced Research Projects Agency, the USAF and NASA. Examples of fore-swept fighter designs include one by Rockwell International's Los Angeles Division (top) and another by Grumman Aerospace Corporation.

9



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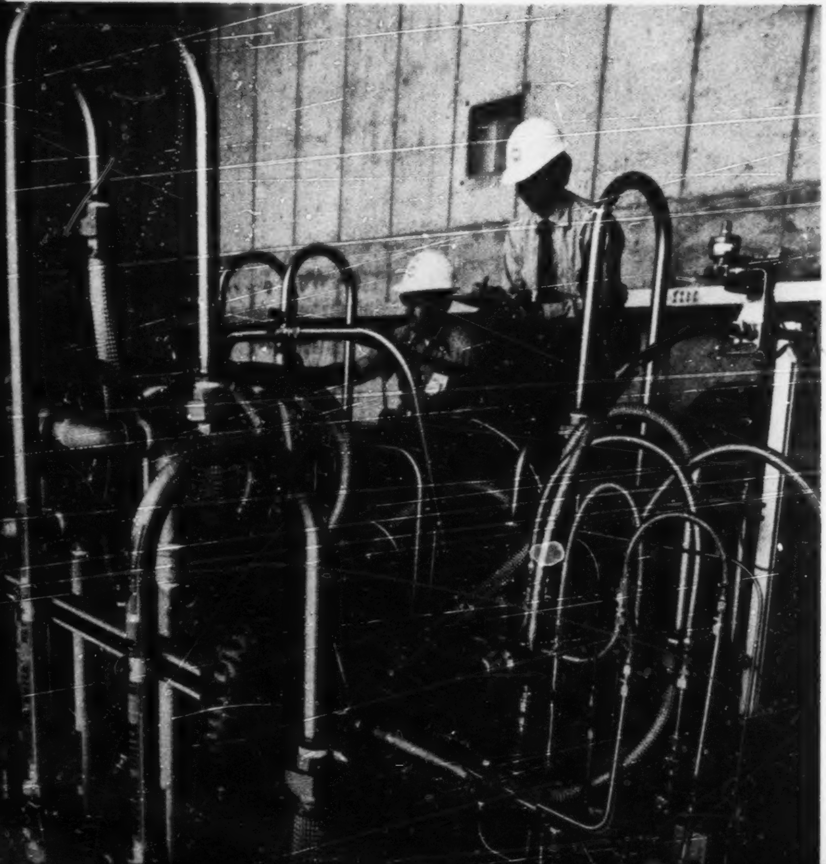
9. Slated to enter the USAF inventory later this year is the KC-10 tanker/cargo aircraft, a long-range, high capacity plane intended to improve the mobility of U.S. forces and reduce reliance on foreign bases. Built by McDonnell Douglas Corporation's Douglas Aircraft Company, the KC-10 is a derivative of the commercial DC-10. With its maximum cargo payload of 85 tons, the KC-10 has a range of almost 4,000 nautical miles; the range can be extended significantly because the trijet can itself be refueled in flight. Used as a tanker, the KC-10 features an advanced refueling boom which can deliver fuel in flight to USAF, Navy and NATO aircraft faster, easier and more safely.

10. Soaring fuel costs have prompted a revival of interest in propellers and sparked research on advanced, swept-blade propellers as means of reducing aircraft fuel consumption. This is an eight-bladed prop-fan system developed by Hamilton Standard Division of United Technologies. Coupled to a turbine engine, it offers airplane speeds comparable to those of jetliners with sharply reduced fuel consumption—up to 40 percent. The reshaped blades also provide a bonus in noise reduction.

11



12

11. Pre-launch checkout and sequencing of launch countdown for the Space Shuttle are controlled by a new computer-based system at Kennedy Space Center (KSC); the photo shows the KSC firing room with its array of processing systems and display controls. Shuttle requirements dictated design of a more automated, yet more graphically explicit system. Technicians will be able to prepare a Shuttle launch in one-twelfth the time needed for Saturn V pre-launch work with fewer personnel. Design and programming of the processor system was handled by IBM's Federal Systems Division under NASA contract; the Division is also producing the Shuttle Orbiter on-board general purpose computer and display systems, and the Shuttle data processing complex at Johnson Space Center.

12. Representative of many aerospace industry energy research projects is this facility used by TRW Systems and Energy in development of an experimental magnetohydrodynamic (MHD) coal combustion system, a key to clean and more effective utilization of coal resources. The system will ultimately be scaled up to generate hundreds of millions of thermal watts of energy; it will burn pulverized coal, seed the flame with potassium to promote ionization, and transmit heat to a conventional steam turbine power plant. The MHD process converts coal to electrical power 50 percent more efficiently than conventional generators—and in an environmentally acceptable manner. Nationwide conversion of coal-fired plants to MHD would increase available electricity by 36 percent.

NAVSTAR

The Navstar satellite orbits at 10,900 nautical miles, its multiple antennas directing position-fixing signals to receiving sets in space, air, land and sea craft. ▶

REVOLUTION IN NAVIGATION

In almost any type of military operation—and particularly in combat—accurate position fixing is very important, sometimes vital. For that purpose, the Department of Defense has developed a variety of systems, each tailored to a specific need ranging from aircraft and submarine navigation to position determination for armored columns and infantry patrols.

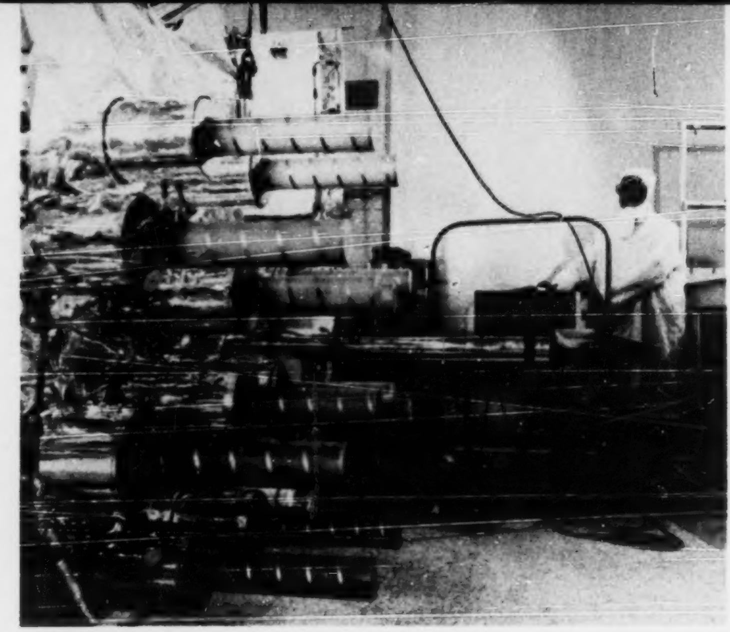
The problem is that there are so many different systems, employing different techniques, providing varying degrees of accuracy and complicating maintenance requirements. For greater operational efficiency and reduced maintenance support costs, DoD saw a need for an advanced, multipurpose, weatherproof, jamproof, superaccurate system that could serve the needs of most users and replace most of the existing equipment. The answer, to be operational in 1985, is the Navstar Global Positioning System (GPS), a network of satellites and related ground equipment which provides space reference points for fixing positions on Earth accurate within 50 feet—an exceptional degree of precision.

Although it has been in development for seven years and in experimental flight status for more than two years, Navstar GPS is little known to the general public. Nonetheless, it is one of the most important military projects under way. "It will," said DoD Under Secretary for Research and Engineering William J. Perry in Congressional testimony, "give the United States a truly revolutionary capability in navigation. It broadens the concept in navigation beyond what we thought of in the past."

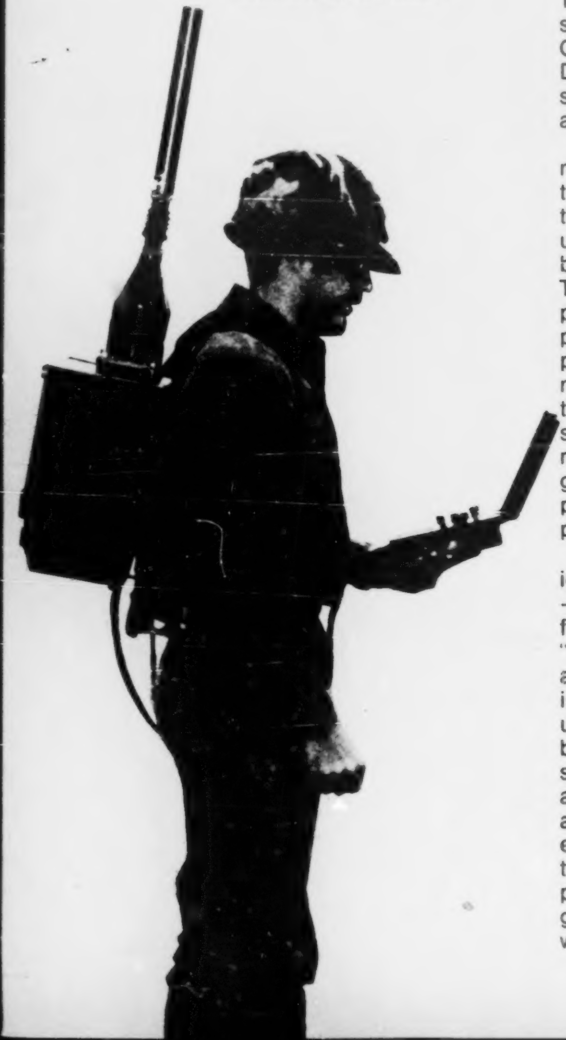
In November, the USAF will launch the seventh Navstar of a developmental series intended to validate the concept and check the system's accuracy with several different types of user equipment. The first four satellites were launched in 1978 and two more went into orbit earlier this year. There will be additional developmental launches and eventually the interim system will be replaced by more advanced operational satellites.

Navstar GPS is composed of three segments:

- The space segment which, when operational, will consist of 18 satellites in three different orbital planes, six in each orbit. Circling Earth twice daily at altitudes above 10,000 miles, the satellites will be so positioned that four of them will be "visible" to land, sea and air users virtually anywhere on Earth under all weather conditions. Current satellites are launched by USAF/General Dynamics Atlas F launch vehicles. Later, Navstar will be delivered to orbit by the Space Shuttle and an upper stage booster; one such booster is being developed by McDonnell Douglas Corporation. Rockwell International's Space Systems Group is prime contractor for satellite development and manufacture; some 40 other contractors are producing subsystems.
- The control segment, consisting of a GPS Master Control Center and four or more widely-separated monitoring stations which will track the satellites and accumulate data from the navigation signals sent from orbit. This information will be processed at the control center for use in satellite orbit determination and error elimination. The control center will also act as a two-way communications link with the satellites, providing informational updates to insure that users will get optimum navigation signals. There are currently four monitoring stations at Vandenberg Air Force Base (California), in Alaska, Hawaii and Guam. The GPS Master Control Center will be located at Fortuna Air Force Station, North Dakota. IBM Federal Systems Division has a USAF contract to improve and develop ground stations.
- The user segment, consisting of equipment aboard ships, aircraft, missiles and ground vehicles; also in development is a manpack system for foot soldier use. Each user set consists of an antenna, a receiver, a signal processor and a display unit. User equipment will vary according to the application; depending on configuration, user sets will cost from $10,000 to $30,000. Contractors building user equipment for the developmental phase are Rockwell's Col-



At Rockwell International's Space Systems Group, an engineer runs through an electronic checkout of a Navstar satellite.



In tests at the Army's Yuma Proving Ground, troops find their locations in the desert within 50 feet by means of 27-pound manpacks which receive and process signals from orbiting Navstars.

lins Government Avionics Division and Magnavox Government Electronics Division.

Air Force Space Division, an element of the Air Force Systems Command, is DoD's program manager. The joint program office has representatives of the Army, Navy, Marine Corps and NATO nations; there is also Department of Transportation representation since Navstar has future applicability as a civil system.

Navstar is a space age version of the mariner's system of celestial navigation—with many major advances. In the pre-electronic era, the mariner used a sextant to measure the angle between his ship and a known star. This enabled him to chart a "line of position," determined by laborious plotting from information in precomputed star tables. To get a "fix," the navigator shot a second star and plotted another line of position; the intersection of the two lines on the chart marked his location on the sea. For good measure, he usually shot a third, perhaps a fourth star to confirm his position.

The GPS does a similar job automatically and instantaneously. Navstar—which stands for Navigation System for Timing and Ranging—is the "known star," but where natural stars are passive reference points, Navstar is an active position-fixing source. The user need do nothing but push a few buttons; his equipment automatically selects the four satellites most favorably located for most accurate results and locks onto their signals. The user's electronic signal processor computes the four satellite-provided lines of position, translating the complicated geometry into positioning information which appears on the display screen: an exact "fix"—latitude, longitude, altitude—within 50 feet; velocity within a small fraction of a mile per hour; and the time of the fix within a millionth of a second.

The basis for the three-dimensional fix provided is the time if takes for the signals from the four satellites to reach the user's receiver. Since the signals travel at the speed of light and the satellites themselves are moving through space at thousands of miles per hour, timing information must obviously be exquisitely accurate. Therefore, a key element of the Navstar system is an atomic clock—actually three of them in each satellite. It is understatement to call these clocks "accurate;" they will gain or lose only one second in 36,000 years.

The Navstar signals may be received by an unlimited number of GPS sets without becoming saturated or revealing the user's position. Among the applications planned are high-precision weapons delivery; en route navigation for space, air, sea and land craft; aircraft runway approach; photomapping; geodetic surveys; aerial rendezvous and refueling; tactical missile navigation system updating; air traffic control; range instrumentation and safety; and search/rescue operations. An example of the potential Navstar GPS provides for reducing the proliferation of defense navigation systems is the fact that a single receiver/processing set aboard an aircraft could achieve or surpass the capabilities of five separate items of equipment—and at lower equipment cost.

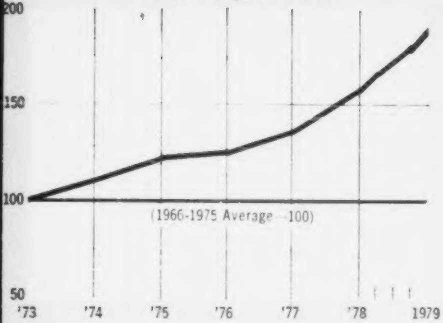
Although Navstar GPS is designed to provide accuracies within 50 feet, it has been doing better than that. In more than 1,000 concept validation and development tests, the satellites have enabled aircraft, ship and ground vehicle position fixing accurate to less than 30 feet—this despite the fact that the interim system has had no more than six active satellites where the operational system will have 18. In Congressional testimony, DoD Under Secretary Perry described results he had observed at the U.S. Army Proving Ground, Yuma, Arizona, test site for user equipment:

"We went for a night flight in a helicopter, and with only the GPS as a navigation aid, we made a blind landing at an airfield at night . . . landing within three or four feet of the X that was on the runway.

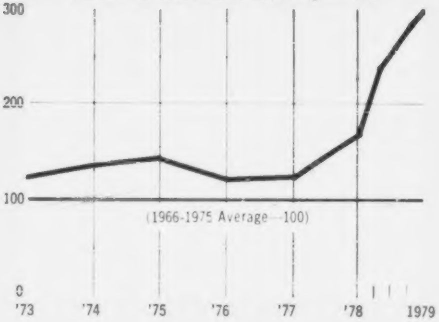
"We watched a C-141 guided only by the GPS satellite and it parachuted supplies to the gound that landed within 30 feet. Finally, we saw a demonstration of blind bombing techniques. This is where the F-4s were dropping conventional bombs within 10 to 20 feet of the target—guided only by the Navstar satellites."

AEROSPACE ECONOMIC INDICATORS

CURRENT

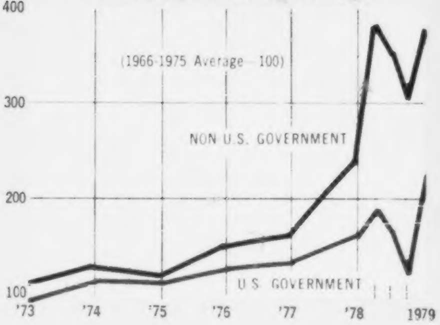


Total Aerospace Sales



Value of Civil Aircraft Shipments

OUTLOOK



New Orders — Monthly Average

ITEM	UNIT	PERIOD	AVERAGE 1966-1975 *	SAME PERIOD YEAR AGO	PRECEDING PERIOD†	LATEST PERIOD 4th QTR. 1979
AEROSPACE SALES: TOTAL	Billion $	Annually	26.6	37.9[r]	43.8[r]	45.8
	Billion $	Quarterly	6.4	10.2[r]	11.5[r]	12.2
AEROSPACE SALES: TOTAL	*Billion $*	*Annually*	*27.3*	*24.2[r]*	*26.2[r]*	*26.8*
(In Constant Dollars, 1972=100)	*Billion $*	*Quarterly*	*6.9*	*6.5[r]*	*6.9[r]*	*7.2*
AEROSPACE PRIME CONTRACT						
AWARDS: TOTAL	Billion $	Quarterly	5.8	14.9[r]	11.9[r]	16.7
U.S. Government	Billion $	Quarterly	4.1	7.3[r]	5.4[r]	9.1
Other Customers	Billion $	Quarterly	1.7	7.6[r]	6.5[r]	7.6
BACKLOG (Major Aerospace Mfgrs): TOTAL	Billion $	Quarterly	28.6	57.1[r]	68.9[r]	75.0
U.S. Government	Billion $	Quarterly	15.9	30.2[r]	33.0	36.2
Nongovernment	Billion $	Quarterly	12.7	26.9	35.9[r]	38.8
DEPARTMENT OF DEFENSE						
Aerospace Obligations: TOTAL	Million $	Quarterly	2,712	4,528	3,737	3,242
Aircraft Procurement	Million $	Quarterly	1,986	3,782	2,985	2,709
Missiles Procurement	Million $	Quarterly	726	746	752	533
Aerospace Outlays: TOTAL	Million $	Quarterly	2,405	2,500	2,928	3,415
Aircraft Procurement	Million $	Quarterly	1,741	2,002	2,346	2,816
Missiles Procurement	Million $	Quarterly	664	498	582	599
NASA RESEARCH AND DEVELOPMENT						
Obligations	Million $	Quarterly	780	1,107	903	1,104
Expenditures	Million $	Quarterly	789	732	874	874
EXPORTS						
Total (Including Military)	Million $	Quarterly	1,038	3,227	3,019	3,088
New Commercial Transports	Million $	Quarterly	345	1,166	1,488	1,271
EMPLOYMENT: TOTAL	Thousands	End of Quarter	1,166	1,031	1,121	1,152
Aircraft	Thousands	End of Quarter	650	572	618	637
Missiles & Space	Thousands	End of Quarter	114	84	100	103
AVERAGE HOURLY EARNINGS, PRODUCTION WORKERS	Dollars	End of Quarter	4.38	7.94	8.39	8.75
PROFITS						
Aerospace — Based on Sales	Percent	Quarterly	2.7	5.1	5.2	5.1
All Manufacturing — Based on Sales	Percent	Quarterly	4.8	5.6	5.7[r]	5.3

* Quarterly average computed as one-fourth of annual average.
† Preceding period refers to quarter preceding latest period shown.
r Revised.

Source: Aerospace Industries Association

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